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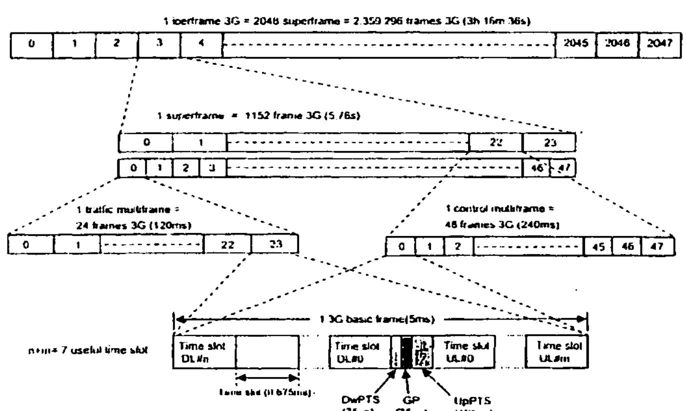
(54) Title: ACCESS CHANNEL SCHEDULING IN A RADIO COMMUNICATION SYSTEM

FRAME STRUCTURE IN 3G SYSTEM



(57) Abstract: A process for the access channel scheduling to radio channels shared by a plurality of Mobile units of an UMTS mobile telecommunication system. Said process allowing to a mobile unit to access to the base station (BTSC) and signal the assignment requests of a dedicated channel, or to have direct access to the new channel in case of asynchronous intercell handover. The process consists in marking a basic TDMA-CDMA frame within the multiframe, with periodicity and phase that can be separately controlled. The aggregate of the marked frames having equal phase forms a subchannel shared by the Mobile units to perform a specific access typology associated to that subchannel. The access takes place through the transmission of a signature sequence, random selected by the Mobile units among a plurality of different sequences associated to the carrier used in the cell. To mark the frames of a subchannel, an expression of the following type is used: SFN module [P1]=P2, where SFN is the System Frame Number and P1 and P2 are two parameters signalled at first by the network in a System Information message broadcast diffused by the BTS in a common control channel, or time by time included in the following messages: Paging Request, Immediate Assignment, Handover Command, Uplink free.

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"ACCESS CHANNEL SCHEDULING IN A RADIO COMMUNICATION SYSTEM"

Field of the invention

The present invention relates to the mobile radio telephone sector, and more in particular, to a process for the regulation of accesses to shared radio channels in a mobile system of the third generation.

Background art

During the last ten years, the mobile radio telephone systems underwent a constant technological evolution that involved a gradual abandon of first generation systems, characterized by analogue modulations of the transmitted carriers, in favour of second generation systems, characterized on the contrary by digital modulations, as well as by an extensive digital processing (DSP) of the basic band signal converted into digital. The time is now ripe for the coming into service of mobile systems of even more advanced conception, the so-called third generation systems, which differ from the previous ones mainly for the different access method to the physical channels by the service users. The design of these systems availed of applications acquired in the military environment, following studies on the feasibility of transmissions suitable to preserve the confidentiality of the information transmitted and to assure a given immunity to the noises caused to sabotage purposes (jamming). The targets have been reached thanks to an artificial widening of the modulation spectrum of the transmission carrier compared to the basic band spectrum. The modulation technique is therefore called spread spectrum technique (spread spectrum) and consists in multiplying each low symbol-rate symbol of the signal to be transmitted with a code sequence, of the pseudo-noise type, at higher chip rate, whose scope is that to spread the information transmitted on a wide spectrum of frequencies, actually making it accessible only to whom is duly authorized to reception. To this purpose, the spread spectrum receiver demodulates the signal received and reconstructs the original data performing a time correlation between the demodulated signal and a local copy of the code sequence used in the modulator. From the mathematical correlation between the symbols of the demodulated signal and the correct code sequence, the original signal at its

maximum level is obtained at the output of the receiver, which therefore is discriminated from the noise and interference. In the civil environment, and more in particular in the field of mobile radio telephone communication, a spread spectrum use of modulation quite different from the previous military targets is foreseen. The peculiar use is to enable the simultaneous sharing of a same physical channel among more users, identified by different spreading codes. The relevant technique, known with the acronym CDMA (Code Division Multiple Access), employs reciprocally orthogonal spreading code sequences, that is whose intercorrelation can be assumed as null. It just enables the discrimination among the different users summing up in the transmission band, since on a channel characterized by its own code sequence the signals of the other channels, as a result of the correlation, will appear as a noise. Compared to the narrow band traditional systems, the spread spectrum technique offers the additional advantage of a higher insensitivity to Rayleigh selective fadings, these last caused by multiple reflections along the path on-air of the signal transmitted, that obtains them from the fact that the spectral fraction concerned in high fading, is only a very small part of the spectrum globally occupied by the useful signal.

The imminent introduction of the third generation mobile telecommunication systems, or UMTS (Universal Mobile Telecommunication System) puts all over the world many great problems of compatibility with the existing PLMN systems (Public Land Mobile Network), among which the more diffused one is no doubt the Paneuropean system GSM 900 MHz (Global System for Mobile communications), and its immediate descendent DCS 1800 MHz (Digital Cellular System). The GSM complies with specifications issued as recommendations by appropriate over-nation organizations (CEPT/CCITT, in ETSI/ITU-T environment) having the purpose to make the operation of the different telecommunication systems uniform in order to make them compatible among them and therefore capable of communicating. The applicant, acting in accordance with the 3GPP organization (3rd Generation Partnership Project) and the Chinese organization CWTS (Chinese Wireless Telecommunication Standards) is pursuing the development of its own third generation mobile telecommunication system based on the CDMA technique. The aim for the near future is to preserve, where possible, the functional characteristics of the GSM, however intervening whenever the impact of the new CDMA technique necessarily requires ad hoc solutions. Consequently, before describing the

embodiment of the invention, it is necessary to describe some operational peculiarities of the GSM system in order to enable to better understand the technical problem that the invention has to solve.

Fig. 1 shows a brief but clear block diagram of the functional architecture of a mobile system of the GSM, or DCS type; the same diagram can also be perfectly used to describe the CDMA system (TD_SCDMA) where the invention that shall be described resides. In fig.1, portable telephone sets, also vehicular ones are indicated with symbols MS (Mobile Station) hereinafter called also Mobile units, radio connected with relevant TRX transceivers (non-visible in the figure) belonging to relevant base transceiver stations BTS (Base Transceiver Station) spread on the territory. Each TRX is connected to a group of antennas whose configuration assures uniform radio coverage of the cell served by the BTS. A group of N adjacent cells, that altogether engage all the carriers available to the mobile radio service, is called cluster; the same carriers can be re-used in contiguous clusters. More base stations of the BTS type are connected through physical carrier to a common base station controller denoted BSC (Base Station Controller). More BTS altogether, governed by a BSC forms a functional subsystem defined BSS (Base Station System). More BSS (BSC) are connected to a mobile switching centre MSC (Mobile Switching Centre), directly or through a TRAU block (Transcode and Rate Adaptor Unit) that enables the submultiplexing of 16 or 8 kbit/s channels on the 64 kbit/s connection lines, optimizing the relevant use. The TRAU makes a transcoding from the 64 kbit/s of the voice to 13 kbit/s of the GSM Full Rate (or to 6,5 kbit/s of the GSM Half Rate) enabling to address them with 16 kbit/s or 8 kbit/s flows.

The MSC block is in its turn connected to a switching centre of the terrestrial network PSTN (Public Switched Telephone Network) and/or ISDN (Integrated Services Digital Network). Two data bases called HLR and VLR, non visible in the figure, are generally located at the MSC; the first one containing the steady data of each Mobile MS, the second one containing the variable data; the two bases co-operate to enable the system to trace a user that widely moves on the territory, extended to different European countries. The BSC station controller is also connected to a Personal Computer LMT (Local Maintenance Terminal) enabling the man/machine dialogue, to an Operation and Maintenance Centre OMC performing the supervision, management alarm, evaluation of traffic measurements, etc., functions called O&M functions (Operation & Maintenance),

and finally to a SGSN block [Serving GPRS (General Packet Radio Service) Support Node] specified in GSM 04.64 for the packet switching data service.

Vertical dashed lines can be seen in the figure marking the limits of the interfaces among the main functional blocks, namely: the radio interface between MS and BTS is indicated with Um, with A-bis that between BTS and BSC, with A-sub the interface between BSC and TRAU, with A the interface between TRAU and MSC or directly between this last and BSC, with T the interface RS232 between BSC and LMT, with O the interface between BSC and OMC, and finally with Gb the interface between BSC and SGSN. The above mentioned interfaces are described in the following GSM recommendations: 04.01 (Um), 08.51 (A-bis), 08.01 (A), 12.20 and 12.21 (O), 04.60 (Gb).

Fig. 2 shows an imminent and more advanced scenario compared to that of fig.1. In fig.2 at least one cell served by a BTS of the GSM system is indicated as adjacent to a cell served by a base station BTSC of the new system called 3G (3rd Generation), which includes the invention object of the present application. On the connection lines among the different blocks, the descriptions of the relevant interfaces are indicated. In the figure we can notice a station controller block BSCC connected both to the BTS and BTSC stations; the BSCC block represents a station controller opportunely modified versus a GSM only BSC to be able to support the new BTSC station (the dashed portion indicates the presence of the modifications). The connection between BSCC and the new BTSC avails of an interface similar to the A-bis. The interface on-air between BTSC and the Mobile units is called Uu to distinguish it from the Um one of the GSM. To the same purpose, the Mobile units are called UE (User Equipment) to mean, under a different name, a different description of the interface on-air and of the Mobile units, that shall be consistent with the different design setting. What can be argued from the scenario of fig. 2 is the Handover possibility between the two GSM and 3G systems (Inter-system handover), supported by the BSCC block supporting the normal Intra-system handover, from which a dual mode and multi band operation of the Mobile user equipment UE derives.

In the design of mobile systems, the aspect that mainly affect the design approach is the choice of the access kind one intends to implement on the physical channel to share the available band over the different users. The more known access techniques are: the FDMA technique (Frequency Division Multiple Access) that performs the frequency division multiple access; the TDMA

technique (Time Division Multiple Access) performing the time division multiple access; the CDMA technique (Code Division Multiple Access) performing the code division multiple access; and the SDMA technique (Space Division Multiple Access) that performs the space division multiple access.

With the FDMA technique each user can avail of its own frequency channel, not shared with any other user for all the time requested by the service, this case called SCPC (Single Channel Per Carrier) is typical of the analogue systems of first generation. With the TDMA technique the whole radio spectrum is assigned to more users at different times, called time slots; during a time slot one user only can transmit and/or receive. With the CDMA technique the whole radio spectrum is assigned to more users at the same time, this technique has been previously explained. With the SDMA technique the whole radio spectrum is assigned to more users at the same time, similarly to what said for the CDMA technique, the discrimination among the different users occurs through acknowledgement of the different arrival directions of radio signals.

In a same mobile system the above mentioned access techniques can be separately used, or altogether to avail of possible synergies. The GSM system employs a mixed technique FDMA-TDMA, which compared to the pure FDMA avoids an excessive use of carriers, while versus the pure TDMA it avoids the construction of frames too long and that cannot be proposed. The new 3G system employs an FDMA-TDMA-SCDMA access that joins the advantages of the GSM to that of the CDMA technique. Both the GSM system and the new 3G system can take advantage from the use of an intelligent antenna, adding to the existing multiplexing also the SDMA one, this is certainly applied in the 3G system.

In PLMN systems the user can send information towards the base station while it receives information from the same. This communication mode is called Full-duplex and can be actuated using techniques both in the frequency field and in the time one. The FDD technique (Frequency Division Duplexing) used in the GSM employs different bands for the uplink path (uplink) and the downlink path (downlink). The two bands are separated by an unused gap band to enable the opportune radiofrequency filtering. The TDD technique (Time Division Duplexing) employs different service times for uplinks and downlinks, concerning all the channels multiplexed in the two transmission directions. If the time division between the two service times is small, the transmission and reception appear

simultaneous to the user. The new system 3G, which the invention refers to, employs the TDD technique.

Any public mobile system (PLMN) that intends to offer a quality standard of the service to the users, which can be compared to that offered by the fix telephone network, shall necessarily be fit with a complex signalling. In the GSM system, as we could notice, the problem has been solved employing ad hoc solutions for the FDMA-TDMA technique. These solutions cannot be directly transferred to the telephone systems according to the CDMA technique, at least concerning the radio interface that is the one having the major impact. We can say that third generation mobile systems are at dawn, therefore several information on the definition of adequate signalling methods circulate only within restricted committees of companies participating in the definition of their own system, and cannot be considered of public domain yet. It is then useful to give a general view of the GSM system (or DCS) which, on the basis of an opinion internationally shared, is the most advanced one as for the variety and quality of the service offered. The next considerations supported by **figures 3 to 10** are addressed to the GSM system (or without distinction to the DCS) from which the present invention intends to stand out, for the organization and use of the signalling channels, particularly concerning the access to the radio channel by the Mobile and Handover, in addition to the different CDMA technique of channels multiplexing (characteristics that considered in itself, can be considered known).

In the GSM 900 system, the available band is subdivided as follows:

- sub-band in the uplink direction (MS → BTS) 880-915 MHz;
- sub-band in the downlink direction (BTS → MS) 925-960 MHz;
- gap band 10 MHz 915-925 MHz; channelling pace 200 kHz; N of carriers per sub-band 173; time slot per carrier 8; No. of full-rate channels 1384; No. of half-rate channels 2768.

In the DCS 1800 system the available band is divided as follows:

- sub-band in the uplink direction (MS → BTS) 1710-1785 MHz;
- sub-band in the downlink direction (BTS → MS) 1805-1880 MHz;
- gap band 20 MHz 1785-1805 MHz; channel band 200 kHz; N° of carriers per sub-band 374; time slot per carrier 8; N° of full-rate 2992 channels; N° of half-rate 5984 channels.

Fig. 3 shows the sequential organization of 8 time slots TS0, ..., TS7, or time slot, within a basic frame indefinitely repeated for the use of a generic carrier among those in use in a cell. The aggregate of a carrier and of a time slot forms a physical channel of the Um interface destined to support an information characterising the channel from the logic point of view. The basic frame of fig.3 includes time slots all coming from a single transmission direction, being a FDD symmetric full-duplexing actuated in the GSM system.

In the figure, we can notice four different burst typologies corresponding to the possible contents of any time slot. The sequential frames are organized within more hierarchical levels observed by all the carriers used in the GSM system. All the carriers transmitted by a BTS carry reciprocally synchronized frames, thus enabling the frequency hopping, that is the interchangeability of the carriers assigned to physical channels, increasing the system flexibility, and simplifying the synchronisation between adjacent cells. This said, starting in the figure from bottom to top, each time slot having 0,577 ms duration, corresponding to 156,25 × 3.69 μs bit duration, carries an information burst containing 142 useful bits, 3 head bits TB and 3 tail bits TB, and a guard time GP without information, 8,25 bits long. The burst can be of four different types according to the scopes (ref. GSM 05.02, paragraph 5.2):

- Normal burst. Includes 2×58 useful bit, redundancy included, and 26 bits of a training Sequence in midamble position used in the estimate of the impulse response of the radio channel, useful to the purposes of a correct demodulation of the radio signal modulated according to the GMSK scheme (Gaussian Minimum Shift Keying). Different midambles are foreseen, particularly in relation to the use of the SDMA technique. The Normal burst is used in traffic channels and in signalling associated to the same. In the voice case, the 2 × 58 useful bits are the final result of a complex manipulation of blocks of 260 bits each, generated every 20 ms at the output of the 13 kbit/s voice encoder. The manipulation, described in a great part in GSM 05.03, includes the following steps: block coding and convolutional coding that introduce redundancy increasing the bits from 260 to 456; reordering and partitioning and diagonal interleaving with 8 time slot depth to spread the burst errors over more bursts, addition of the stealing flag and obtaining of pairs of 2×58 bit sub-blocks; encryption, that is, sum bit by bit to a ciphering

flow; and burst building with addition of the midamble and of bits TB to obtain the access burst. The dispersion of the bits of a coded block over more bursts interleaved with the bits of the subsequent block and of the previous block reduces the bit loss per block, in case of corruption of a burst, improving the possibility that convolutional decoding reconstructs the origin information.

- Frequency Correction burst. This burst includes 142 useful bits at logic level "one" in order to allow the correction of the clock frequency of a Mobile unit when this burst is received.
- Synchronization burst. It includes a 64 bit "Synchronization Sequence" in midamble position and 2×39 Encrypted bits. This burst is received by the Mobile unit with an 8 time slot delay from the previous burst, therefore the Mobile that has already corrected the frequency of its own clock can discriminate the correct position of the " Synchronization Sequence " within the burst received, and then the starting instant of the time slot. The Encrypted bits contain the information necessary to reconstruct the frame number FN (Frame Number), completing the synchronization procedure.
- Access burst. It includes a 41 bit Synchronization Sequence in the starting position, followed by 36 Encrypted bits. The guard period GP has 58, 25-bit duration; moreover there are 7 head bits TB and 3 tail bits TB. This burst, of the short type, is typically used by the Mobile to send the first signalling to the network, for instance to perform an access in an originated call or in the handover, it has therefore lower duration than the previous bursts of the full type, and also the portion of time slot unused results higher. This property actually enables the Mobile to send its message to the network with a non perfectly aligned timing, typically because altered by the propagation delay due to the variable distance between the radio station and the Mobile, without invalidating the seat of the adjacent time slots with the risk to disturb the communications underway.

Continuing towards the upper part of fig.3 it can be noticed that a basic frame TDMA of 4.615 ms duration, includes 8 time slots (TS0...TS7). In the frame of the same information flow, two different sequential multiframes are foreseen, out of which a traffic multiframe of 120 ms duration includes 26 basic frames TDMA, and a control multiframe of 253,38 ms duration, including 51 basic frames TDMA. The two multiframes concur to form a unique superframe of 6,12 seconds

duration, consisting of 1326 basic frames TDMA; and finally 2048 sequential superframes form an iperframe of 2.715.648 basic frames TDMA of 3h 28m 63s 760ms duration. The Frame Number FN radio diffused within the cell is referred to the frame position in the iperframe.

Fig. 4 shows the organization of the logic channels supported by the frame structure TDMA of fig.3. Making reference to fig.4 we notice that the set of logic channels foreseen includes a class of traffic channels TCH and a class of control channels. TCH channels are of the full-rate TCH/F or half-rate TCH/H type depending on the fact that a single logic channel or two alternate links are assigned to the relevant time slot, or according to the channel coding used.

The control channels class includes the following main channels: a Broadcast Channel BCCH (Broadcast Control CHannel), a Common control channel CCCH (Common Control CHannel) and some dedicated Control channels DCCH (Dedicated Control CHannel). The BCCH channel includes three subchannels: a BCCH subchannel in a narrow sense, a synchronization subchannel SCH (Synchronization CHannel), and a Frequency correction Channel FCCH (Frequency Correction CHannel). The CCCH channel includes three subchannels: a shared access subchannel RACH (Random Access CHannel), a grant subchannel AGCH (Access Grant CHannel), and a paging one PCH (Paging CHannel). Dedicated control channels DCCH can be divided into two classes, that of "stand alone" channels SDCCH (Stand-alone Dedicated Control CHannel), and that of traffic associated channels ACCH (Associated Control CHannel). This last class includes two channel typologies, of low associated SACCH (Slow ACCH), and fast FACCH (Fast ACCH) type, respectively. After the general listing of channels it is worth to examine the same from the point of view of their formation and application.

- The TCH/F traffic channels are bi-directional channels assigned to the Mobile units that have completed the access procedure to the network in call originated, or ended; are subject to Handover and to frequency hopping. They employ the Normal burst to transport the payload consisting of 13 kbit/s coded voice or data, circuit or packet switching, with net bit rate up to 9,6 kbit/s.
- traffic channels TCH/H carry voice coded at 6,5 kbit/s, or data, at circuit or packet switching, with net bit rate up to 4,8 kbit/s. Compared to the previous ones, they have a lower quality.

- The control channel BCCH is a downlink unidirectional channel, point-multipoint, availing of time slot 0 of a carrier f0, said carrier BCCH. This channel is unique in the cell and is subject neither to Handover nor to frequency hopping. The channel BCCH in a narrow sense, is used to diffuse general use system information, such as for instance: the configuration of channels within the cell, the list of BCCH carriers of the adjacent cells on which performing the level measurement, the identity of the Location Area and some parameters for the Cell Selection and Reselection activity, the complete Cell Identity, parameters for the operation of Mobile units in Idle Mode, and finally of the so-called RACH CONTROL parameters used to schedule the access attempts of the Mobile units on the RACH channel. FCCH and SCH channels, carried by the Frequency Correction burst and by the Synchronization burst, respectively, are used by the Mobile units, in sequence, to synchronise the frequency of their own carrier, the starting of the locally generated frame (starting of the time slot 0), and the position of the same in the iperframe. In a TDMA system it is fundamental that the burst just falls in the assigned time slot, subject to interference generation in the adjacent time slot, this requirement shall also be checked during the moves of the Mobile. The BTS actuates to this purpose a procedure called ADAPTIVE FRAME ALIGNMENT (described in the recommendation GSM 04.03) through which it instructs the Mobile on the extent of the transmission advance in order that it receives a time slot on the uplink frame with a constantly fix delay of three time slots versus the transmission by the Mobile, notwithstanding the variability of the round-trip delay due to the variability of the MS distance from BTS. The SCH channel includes a BSIC field (Base Station Identity Code) with the cell identification, useful to the Mobile to identify the BCCH carrier of the serving cell from the BCCH carriers of the adjacent cells. The control channel CCCH is a bi-directional channel serving the whole cell, it is subject neither to Handover nor to frequency hopping and employs the time slot 0 of the f0 carrier. The RACH shared access channel exists in the sole uplink direction to send the access requests of the Mobile units random distributed in time, towards the network; it is carried by the Access burst. The multiple access can generate disputes on the possession of the channel that shall be solved, for instance, through a "slotted ALOHA" procedure, as indicated in GSM 04.08.

- The two AGCH and PCH channels of the point-multipoint type exist in downlink direction only and carry the answers of the network to access requests made by the Mobile units on the RACH channel, and the so-called paging messages sent by the network towards the Mobile units in ended call procedures, respectively.
- The dedicated control channels DCCH are bi-directional channels of the point-to-point type, subject to Handover and frequency hopping. They can carry signalling with bit rate ranging from 333,3 and 8000 bit/s.
- The " stand alone " channels SDCCH transport the signalling for the network functions, such as affiliation, etc. and for the control of calls up to the TCH channel assignment. One SDCCH channel is assigned immediately after the access of a Mobile to the network.
- The channels ACCH, SACCH and FACCH respectively, are included in the same multiframe of the associated traffic channels. More in particular:
  - A SACCH channel carried in uplink direction the transmission measurements made by a Mobile on the signal received by the serving BTS and by the adjacent cells; in downlink direction it carries system information and different commands for the Mobile, such as timing advance, power control, etc, concerning the relevant TCH and (first) SDCCH channel, as well as the information of the adjacent cells.
  - A FACCH channel is obtained through interleaving of the bits of its own channel TCH (bit stealing), and can therefore be used for a signalling with speed requirements higher than that of SACCH channels.

Fig. 5 shows two possible configurations of the logic channels inside the multiframe in case of medium/small BTS, that is equipped with a few transceivers, and in the case of medium/large BTS. The figure includes a Legend that makes it self-explanatory to the purposes of description. The 26-traffic-frame and associated signalling multiframes 1) and 1') are of course identical in the two cases, which differ in the 51-control-frame multiframes. During the frame idle (–) of the multiframes 1) and 1') the Mobile units perform power measurements on the BCCH carriers of the adjacent cells, and acquire also the relevant FCCH and SCH channels for a pre-synchronization (frequency, time slot, frame number, BSIC) in view of possible Handovers. These measures are possible due to the fact that the lengths 26 and 51 of the two multiframes are expressed by prime

numbers between them, so that there is the assurance that the channels to monitor of the adjacent cells shift in the acquisition window. It can also be noticed that channels FCCH and SCH emitted downlink on time slot 0 always occupy two adjacent frames that follow one another at intervals of about 45.6 ms; this time is reasonably short, in line with the synchronization requirements of a Mobile having access for the first time to the network, or remaining in Idle state. Concerning the access channels RACH (CCCH), we see that they occupy the whole uplink multiframe 3), or a great part of the uplink multiframe 5). This is possible since they are the sole channels of the TS0 group in uplink direction. The remaining time slot 0 channels in downlink direction, that is: BCCH in a narrow sense and CCCH (AGCH, PCH) are present in groups of four successive basic frames, with priority of CCCH groups. Compared to small BTS, medium/large ones require a control channel distribution on two subsequent multiframes.

The control logic channels of the interface on-air Um, organized for instance as shown in fig.5, route the information in two propagation directions as messages exchanged between the Mobile and the network. This information passes over the frame of the Um interface and concerns, more or less, the remaining parts of the network visible in figures 1 and 2. To enable a regular operation of the complex mobile system GSM it is necessary that messages be regulated both in the shape and in the flow through an appropriate protocol.

Fig. 6 shows the diagram of a protocol having several hierarchical levels used by the GSM system to manage the telephone signalling present at the different interfaces. For a great part, the protocol has been obtained from the one presently in use in mobile analogue systems TACS and in PSTN telephone systems, adjusting it to the new requirements of the interface on-air Um and to those deriving from the moving of users. Some blocks (PHL, MAC, RRM) have been marked with a dashed line to indicate that the 3G system employs a suited version of the specified protocol. The level structure enables to subdivide the signalling protocol functions in groups of superimposed blocks on the control plane (C-Plane), and to describe the same as a succession of independent stages. Each level avails of the communication services provided by the lower level and offers its own services to the higher level. Level 1 of the above-mentioned protocol is strictly tied to the type of physical carrier used for the connection to the two sides of the different interfaces; it describes the functions necessary to transfer the bit flows on the radio connections to the interface Um

and on terrestrial connections to A-bis and A interfaces. Level 1 of terrestrial connections is described in recommendations CCITT G.703 and G.711. Level 2 develops functions controlling the correct sequential flow of messages (transport functions) in the aim of implementing a virtual carrier without errors between the connected points. Level 3 (called network level), and the higher levels, develop processing functions of the messages for the control of the main application processes. **APPENDIX APP1** includes a **Legend** with the terminology used in fig.6 and two tables describing the function of the blocks in fig.6, respectively referred to level 2 **(Table A)** and level 3 **(Table B).**

At this point, the main elements helping the operation of the GSM system have been introduced, it is then worth briefly examining some typical functions started by the activity of MS Mobile units sets, the execution method of these function shall be then compared to that of similar functions referred to the context of the invention.

In the mobile telecommunication system GSM the Mobile equipment MS performs a given activity also in "Idle Mode", that is, when no dedicated channel has been allocated to the same. In fact, the Mobile has the need, as first step to be able to communicate through the network, to continuously select a cell to associate with, during its moves. The above mentioned activity falls under the "Cell Selection" function, described in recommendations GSM 03.22 and 05.08. An additional requirement is that to monitor the paging messages to answer to a possible ended call.

In case of "Cell Selection" the Mobile selects the cell to which associate with, making a scanning of the BCCH carriers it is able to receive from a given number of cells more close to its position within the cluster. This is made according to the method already mentioned, through the synchronization and reading of the content of BCCH broadcast channels. For each BCCH carrier the Mobile measures the power and quality of the signal received in order to update a list of six more favourite cells at least. The first cell in the list is the most reliable one and that to which the Mobile associates. The MS access to the network occurs in the following cases:

1. on self-initiative of the user in origin call;
2. on self- initiative of MS on signalling of the network in ended call;
3. on initiative of MS on signalling of the network through transmission of a Handover command, the handover shall be described in short;

4. on self- initiative of MS without action neither of the user nor of the network, in case of particular functions such as for instance: affiliation, authentication, etc., which shall not be treated hereafter.

Fig. 7 shows a Message Sequence Chart relevant to the case of call originated by the Mobile and with successful result. In order:

- The Mobile that wants to have access to the network sends a CHANNEL REQUEST consisting in an Access burst on the control channel RACH. To minimize the collision probability the burst employs to the access a packet of 8 bits only, some of them random assigned. These last, mark the request as an address for the next discrimination of the backward message (MS shall send the complete identification after allocation to the same of a dedicated channel). Concerning the protocol enabled in the mobile, the sublevel 3 CM (fig.6) receives the set-up request and initializes a connection MM. The sublevel MM shall allocate a transaction identifier and shall request the start of a RR connection.
- In reply to the CHANNEL REQUEST the network sends an IMMEDIATE ASSIGNMENT message on the AGCH channel, whose content includes: the channel description, the time advance (TIME ADVANCE) according to which the Mobile has to transmit the subsequent time slots, the maximum transmission power, the frame number FN (FRAME NUMBER) in which the Access burst has been received, a reference that enables all the Mobile units waiting for a similar message on the AGCH channel to know if they have been selected or not.
- The Mobile receives the "IMMEDIATE ASSIGNMENT" message and behaves accordingly, afterwards it sends on a service request message CM SERVICE REQUEST on the SDCCH channel that shall employ up to the assignment of a TCH channel. Note: The whole signalling made on the SDCCH channel can however be made on the TCH channel if the "direct-TCH-assignment" mode is enabled.
- The network establishes a handshake phase to authenticate the identity of the Mobile checking the correct IMSI (International Mobile Subscriber Identity).
- The network establishes a handshake phase to define encryption on the RR connection. The encryption method employs the ciphering algorithm A5

(Ciphering method) described in GSM 03.20. According to this method the level 1 data flow transmitted on DCCH or TCH is obtained summing up bit by bit the data flow of the user with a ciphering bit stream generated by algorithm A5 using a key, called "Ciphering Key", determined as specified in sub-clause 4.3. For a correct synchronization, the algorithm A5 needs to know the TDMA FRAME NUMBER. The deciphering method (Deciphering method) applies the same phases of the ciphering method on the signal received, but in the reverse order.

- The mobile station MS starts the call sending before a SETUP message to the network, that accepts the call starting answering with a CALL PROCEEDING message.
- The network sends an ASSIGNMENT COMMAND to MS for the assignment of a TCH channel with the associated SACCH and FACCH in place of the SDCCH channel. The Mobile answer at assignment made.
- The network sends an ALERTING message to the Mobile to inform that the alerting procedure of the user has started at the location called.
- The network sends a CONNECT message to the Mobile to inform that the call has been accepted at the remote terminal and the connection has been established in the network.
- The Mobile answers with a CONNECT ACKNOWLEDGE message and the call enters the conversation status.

Fig. 8 shows a Message Sequence Chart relevant to the case of ended and successful call towards the Mobile. The procedure is quite similar to the previous one, from which it differs for the following:

- a PAGE REQUEST message is sent by the network on the paging channel PCH.
- The Mobile answers with a CHANNEL REQUEST consisting in an Access burst on the control channel RACH.
- In reply to the CHANNEL REQUEST the network sends an IMMEDIATE ASSIGNMENT message on the AGCH channel including the PHYSICAL INFORMATION.
- The mobile requests the service sending a PAGE RESULT message on the SDCCH channel it shall use up to the assignment of a TCH.

- Authentication and ciphering /deciphering phases as those already mentioned follow.
- The handshake phase of call start is started by the network with a SETUP message to which MS answers with a CALL CONFIRMATION message.
- The ALERT message of call confirmation is sent by MS.
- The handshake phase of call ACCEPTED is now started by MS.

At each instant both the Mobile and the network can require the release of the call sending a DISCONNECT message. For instance, if MS has originated the completion, the network will answer with a RELEASE message and request to end the transaction. The Mobile shall confirm the release of the call with a RELEASE COMPLETE message. When all the connections of the CM sublevel (fig.6) are completed, the network releases the associated traffic and signal channels assigned.

Finally, three important functions of the GSM system are described, called "ADAPTIVE FRAME ALIGNMENT", "POWER CONTROL" and "HANDOVER" functions, based on the execution of particular transmission measures by the Mobile units and/or BTS. Information on this respect is given in GSM 05.08 recommendations. The three functions are also made when a particular function called "Discontinuous Transmission" is actuated, according to which the Mobile, and possibly the BTS, are enabled to the carrier transmission only if it results modulated, for instance, if any activity is in progress on TCH channels. The purpose of this last function is to reduce the average interference level within the network and concurrently increase the operation autonomy of the Mobile units. In the case of "Discontinuous Transmission" measurements are made and averaged, only on 12 out of the 104 frames of the SACCH channel certainly always present.

The transmission measurements made by MS, in downlink direction, concern the level and quality of TCH and SDCCH channels used, and the level of BCCH carriers of adjacent cells. The above mentioned measures generate values sent to BTS on SACCH channels. More in particular, each MS performing measures on a TCH/F channel calculates a mean of the measured values extended to a SACCH multiframe of 104 basic frames, corresponding to a time of 480 ms approx., the mean is included in the SACCH channel of the subsequent multiframe.

The transmission measures made by BTS, in the uplink direction, concern the level and quality of TCH and SDCCH channels in use, the value of the TIMING ADVANCE parameter, and the interference on free time slots. Also in this case, for each MS which the measures are referred to, the measured values are averaged on the SACCH multiframe, the mean calculated by BTS is associated to that calculated by MS and the two means together are sent to BSC through the interface A-bis to be used in the Power Control and Handover functions and, limited to the TIMING ADVANCE, to the frame alignment function.

The Power Control function consists in the gradual variation of the power of a transmitter by steps having width previously set. The power control is governed by BSC and is compulsorily made on the Mobile units and optionally on the TRX of the BTS. It occurs on all the time slots relevant to traffic TCH and control SDCCH channels, separately for each single channel and for each single MS; the time slots of BCCH carriers carrying control channels are excluded, being always transmitted at the maximum power. Considering the Power Control made on the Mobile units, two cases are possible, out of which: in a first case the transmitter power is decreased by steps having pre-set width up to reaching a minimum level adequate to the transmission conditions within the serving cell; in a second case the power is increased with the same methods up to reaching the maximum allowed output level of the transmitter. In the first case, the purpose is to reduce the interference level on each channel, making feasible in practice also very small cells; secondly it increases the operation autonomy of the Mobile units. In the second instance, the purpose is that to avoid Handovers due to radio reasons when they could be actually avoided. The power emitted by the BTS on each time slot of each radio carrier can have a level (Emission Level) depending on the distance that separates BTS from MS, said distance is assessed on the basis of the TIMING ADVANCE parameter which, through a simple calculation, enables to obtain the Mobile radial distance and therefore the path loss. The commands for the control of Mobile transmitters run on SACCH channels at rates of approximately two commands per second and enable a maximum variation of power transmitted of 2 dB every 60 ms, from which it can be noticed that deep (> 12 dB) and sufficiently extended fading cannot be compensated with a sole command.

The ADAPTIVE FRAME ALIGNMENT procedure is performed by BTS to maintain three fixed advance time slots between downlink and uplink frames. The

three time slots enable to avoid the double filter at the antenna of transceivers and to simplify the manufacturing of the equipment. When a dedicated connection is established, BTS continuously measures the time difference between its bursts and those received from MS, the mean of these measures corresponds to the TIME ADVANCE parameter entered in the SACCH channel and downlink transmitted twice per second approximately. The Mobile MS employs the value received for the correction of the time advance to send its own burst. The maximum allowed correction is 235 μs, sufficient to provide cells with 35 Km radius without setting excessive limits to the speed of the Mobile units.

Ultimately, it is examined the Handover procedure whose execution enables the network to give a command to a Mobile operating in "Dedicated Mode" to force it to go to another channel of cell. The handover is an essential function for any mobile telephone system, being the function that enables the Mobile to communicate though making large territorial moves during the communication. In fact it prevents the degrading of the transmission quality of the communication channel, which would otherwise inevitably occur due to the gradual moving away of the Mobile from the complex of antenna of its own cell initially serving. The prevention action has also to be accomplished without the users can perceive a noise on the communication underway.

A first criterion characterising the Handover is the localisation of the "switching point" in the infrastructure, where for switching point it is intended an entity in the hierarchical structure that links up the functional entities before and after the handover. Hereinafter, the suffix "old" shall indicate all the functional entities on the communication path, before the handover, and "new " those after the handover. In the GSM system, the handover is started by BSC if the reason is a poor transmission quality on the channel in use; it is requested and governed by MSC if the reason is due to the too heavy traffic within a cell; and finally can also be requested by the Operation and Maintenance Centre to perform some O&M functions. As far as the typology of Handovers is concerned, if they are made among channels of the same cell, they are called "Intracell", if on the contrary they are made among channels of different cells they are called "Intercell". An Intracell Handover involves an MS and a BTS and is generally governed by the BSC controlling the BTS. A Handover Intercell involves an MS and two BTS and can be of the internal or external type, depending on the fact that the two BTS belong to a single, or to two different BSC. In the first case the

handover can be governed by the same BSC, in the second case it must be governed by MSC.

A second criterion characterizing the Handover is in the TIME ADVANCE determination method to be used in the new cell. On the basis of the above mentioned method we can distinguish two types of Handover: a synchronous Handover, if made among cells synchronised at iperframe level, and an asynchronous Handover in the contrary instance. In the synchronous case the Mobile can calculate by itself the TIME ADVANCE to apply in the new cell, while in the asynchronous case it must send an appropriate Access burst on the dedicated channel to enable the new BTS to calculate the correct TIME ADVANCE. The Handover execution times shall of course be lower in the first case, not higher than 100 ms, and approximately double in the asynchronous case.

Fig. 9 shows a Message Sequence Chart relevant to the case of a successful asynchronous inter-BSC Handover where, for brevity, all the protocol phases relating to the protocol entities generically called "NETWORK" have been neglected. The synchronous handover can be read in the same figure where the reception phase of PHYSICAL INFORMATION by MS is deleted. Making reference to fig. 9, the procedure develops as following:

- The network, once completed a protocol phase that largely depends on the causes originated by the handover and by the switching point, prepares a message addressed to the new BSC containing all the information necessary to the same in order that it provides a new channel for the handover. When the new BSC has operated as indicated above, it sends to the old BSC a HANDOVER COMMAND with the indication of the allocated channel and of all what required by the Mobile to place at first on the new channel, even if in a non perfect manner. This command is sent to the Mobile by the old BSC to which the Mobile itself is still connected, using to this purpose an associated FACCH channel. The content of HANDOVER COMMAND includes: the BSIC of the new cell, the Handover type (Intra-system or Inter-system, synchronous or asynchronous), a handover reference, the frequency and number of time slot to employ, and the transmission power, of course cannot include the TIME ADVANCE and the FRAME NUMBER that shall be known only after synchronization.

- The Mobile temporarily abandons the old channel and switches on the new channel TCH of the new cell, where it makes an access sending a HANDOVER ACCESS burst. The burst is 8 bit long, like the one sent to the RACH channel by a mobile already associated to the cell, but contrarily to the same, it now includes a Handover reference.
- the HANDOVER ACCESS command is reiterated by the Mobile 4 times if the handover is synchronous and up to reception of a PHYSICAL INFORMATION message, or at the time out of the count of a Timer T3124 if the handover is synchronous.
- The. mobile receives the PHYSICAL INFORMATION independently transmitted by the new BTS on the FACCH channel and ends the transmission of HANDOVER ACCESS. The PHYSICAL INFORMATION contains the TIMING ADVANCE that the Mobile has to apply and is repeatedly transmitted by the BTS after reception of the HANDOVER ACCESS message that enabled it to calculate the same. The BTS stops transmitting the PHYSICAL INFORMATION when it decodes a Level 2 frame or a TCH block, which makes evident it has been received. At this point the Mobile is able to perfectly synchronise itself to the new multiframe and adjust the transmission timing advance and the power level.
- The Mobile sends a HANDOVER COMPLETE message on FACCH channel towards the new BTS, following which MSC communicates to the old BSC that it can release the old traffic channels and associated signalling.

Fig. 10 shows a brief procedure, in handshake form, to shows the failed Handover case, whether synchronous or asynchronous. In practice, if following the reception of the HANDOVER COMMAND message the Mobile cannot receive the PHYSICAL INFORMATION from the new BTS within a time foreseen, it switches on the old channel of the old cell and sends a HANDOVER FAILURE message to start a Call Re-Establishment procedure.

The description of the technical characteristics of the GSM system considered more important for the comparison with the present invention ends here. Now some aspects are circumscribed that appear just from now to be drawbacks versus the CDMA technique in general; other aspects highlighted are equivalent to mere and simple observations of the characteristics that will result

to be dissimilar in the description of the embodiment. What we want to highlight here is the following:

- The FDMA-TDMA technique of the GSM with 200 kHz distant channels, unless to have recourse to a multi-slot configuration that deviates from the standard architecture and requires a particular planning, would limit the bit-rate at disposal of the single user at 9,6 kbit/s for data and 13 kbit/s for voice, values that are not fit to future requirements to offer broad band services to the users.
- In the GSM, the particular shared access technique and the comparatively low bit frequency, do not set stringent restrictions on synchronism. For this reason, rather slow mechanisms are foreseen in the research and holding of the synchronism in Idle Mode and in Dedicated Mode respectively. The synchronization is in fact promoted by BTS through the emission of a copy of FCCH and SCH signals in the downlink multiframe at intervals of approximately 45.6 ms. The holding of the synchronism of the Mobile in Dedicated Mode foresees the emission of the TIMING ADVANCE correction parameter by BTS on SACCH channels at intervals of approximately twice per second. These synchronization mechanisms would go through a crisis in a 3G system of the TDD type [for instance: TD-SCDMA or TDD UTRAN (UMTS Terrestrial Radio Access Network)], characterized by well higher bit-rates and very stringent restrictions of the interference generated due to a too loose synchronization. This because the access technique foresees more co-located users, so that a dissynchronism among them can generate reciprocal interference.
- The random access mechanism to the network in the GSM is separated from the synchronization mechanism (which before and during this phase is essentially downlink), consequently an uplink synchronization concurrently with the access is not requested. What said can now appear not so clear in lack of a description of the 3G system, but it is important to put the subject forward because it has implications to the purposes of the invention object of the present application. The raised subject derives from the different setting of Level 1 between the two mobile systems, more than from advantages or drawbacks. The different setting of physical channels creates in the 3G system additional collision problems during the random access to the

network compared to the GSM, problems that occur also for the asynchronous handover, things that does not occur in the GSM.

- In the full-duplex access of the FDD type implemented in the GSM, the uplink multiframe is identical to the downlink multiframe, so that a symmetry relation in the number of traffic channels and associated control in the two transmission directions, forcedly exists. This setting is not the best in coping with situations in which the traffic is highly unbalanced, such as for instance in connections with INTERNET in which the more engaged path is no doubt the downlink one.
- The physical resource associated to a GSM channel is fix and cannot be modified, therefore it is not possible to dynamically vary the capability of the channel to face the changed traffic or message requirements.
- Specific level 1 fields are not foreseen in GSM burst to make the power control or the transmission advance. These functions are carried out keeping SACCH channels busy at intervals of approximately twice per second, too slow to remove the Rayleigh fading and suitable to remove only the log-normal attenuation. In the GSM, the Power Control is used to reduce "on an average" the total interference level, since, if a good planning of the cells has been made, the user should not share the burst with other potential isofrequential interferents. Differently, in the 3G system the shared use of a time slot and of the band in CDMA technique, in practice makes the interference of the isofrequential type. Therefore a faster and more accurate Power Control is requested because the tolerated interference degree is lower. In this context the degree of reciprocal interference would be minimized equalling "burst by burst" the power received from the single isofrequential users and make the CDMA technique reliable.

The CDMA technique is preferred in the third generation systems just because it can avoid the drawbacks of the GSM highlighted before, particularly those due to the low bit-rate, to the need to have an accurate planning of the frequency, to the inability to efficiently manage asymmetric traffic. As already said in the preamble, different companies of the sector are fostering for the third generation systems, the near future target is that of a reciprocal agreement to produce a number of universal specifications UMTS greatly detailed, as it was done in the past for the GSM in the sole European environment. At present the IS-95 standard is in force for a CDMA system foreseeing the use of 64 coding

orthogonal sequences called also Walsh functions. In addition to these ones, Pseudo-Noise (PN) sequences are foreseen such as for instance the "long code" for the user identification, and pilot sequences PN transmitted by the base station for its own identification. The Walsh 0 function is employed for the pilot channel. The remaining 63 Walsh coding are used for the synchronization channels (Synch channels), of call (Paging channels) and of conversation (Traffic channels). Before the content of the information in the form of data is encrypted with a Walsh code and subsequently wide spectrum modulated, a partition of the content is made through channel coding, Interleaver and Long Code. The data speed at the encoder input can range from 1200 to 9600 bit/s. All the channels of a base station CDMA form the so-called "forward link", which in practice is the signal transmitted towards the Mobile units. In the opposite direction, the signal transmitted by the mobile differs from that of the base station for the different channel coding and the type of modulation used (Offset-QPSK). The pilot sequences PN, which in the receiver of the mobile are synchronised at the pilot signal of the base station, are used again to spread-spectrum modulate the modulation data. Another characteristic differentiating the signal of the mobile is that this last does not transmit any pilot signal. A closed loop control of the transmission level is foreseen, between the base station and all the active Mobile units, to compensate the variability of attenuation due to the different distance from the antenna and channel fading. Through this control, the transmission power of all the Mobile units can be adjusted, in such a way that the intensity of signals at input of the receiver of the base station has approximately the same level.

According to this specifications all the channels share the whole band in pure CDMA technique, that is, without having additional recourse to other multiple access techniques. This applies also to the full-duplexing that foresees to use a different modulation type and a different channel coding for the signal transmitted by the mobile compared to that transmitted by the base station, maintaining of course, the same Walsh function. It is rather evident that the system specified in the IS-95 is still far from being classified as third generation system UMTS. In fact, the main requirements requested are missing, in particular those of the high bit-rate at disposal of the single channel, the possibility of asymmetric traffic on the two paths, and the possibility of dynamically varying the spreading factor. Moreover, the full-duplex methods adopted, which do not fall

under the canonical FDMA and TDMA schemes, could cause cross-talk interference (cross-talk) among the different channels. Concerning the synchronization of Mobile units, the transmission of the pilot signal PN corrects the oscillator frequency of the Mobile units and the phase of bits transmitted, presumably using the known PLL mechanisms, since, being hierarchical frames missing, it is not necessary to align the bursts and the frames. Moreover, in the opinion of the Applicant this specification is scarce in defining all the complex problems concerning architecture, signalling, and actual realization of a UMTS system that is really competitive with the present GSM, which always remains the milestone for comparison. Ending with the system in specification IS-95, it can be reasonably stated that the specified system, though in CDMA technique, does not offer any more qualifying teachings to evolve towards a third generation system, than those supplied by the GSM system itself. It is not a case that the manufacturers' need is to reach a new sector standard.

Some subjects that arise in the design of a third generation system, whose answer can condition the design choices, are highlighted here below.

- A first point is how to vary the means that enable the mobile unit to synchronise at the radio frame versus those of the GSM, which would be inadequate in the new context.
- A second point is that of how employing the new synchronization means in the protocol steps foreseeing an access of the Mobile unit to the radio frame of the serving cell, or adjacent cell in case of handover.

Considering the complexity of the subjects treated, at this point of the description it is not possible to anticipate in a more accurate way the technical problem that the present invention intends to solve in an original way. As progressing with the description of the embodiment, the technical problem shall be fully and clearly highlighted, so as to completely legitimate the solution means implemented by the present invention.

Object of the invention

Therefore scope of the present invention is to indicate a process for the regulation of accesses to shared radio channels that, in line with the time and power synchronization modes imposed to physical channel by the system choices at the radio interface of the new system UMTS, avoids dangerous congestion on the channel shared by the Mobile units when performing the access to the network in the procedures foreseeing the same.

Summary of the invention

The main object of the present invention is a process for the regulation of accesses to radio channels managed by a base station belonging to a mobile telecommunication network ot the UMTS type, as described in claim 1.

Further objects of the invention are two additional embodiments of the process, described in the appended claims.

An additional object of the invention is a mobile system performing the access regulation procedure of claim 1, and of the two said embodiments.

Advantages of the invention

The process of claim 1, thanks to the introduction of subchannels dedicated to the different access typologies, confers a CDMA system the capability to regulate the access of the Mobile units on the shared channel, and in particular to the TDMA-CDMA system of the present invention. It is thus attenuated the risk to congestion the uplink path in the peaks of connection requests to the network, concerning all the modes foreseen by the system, such as for instance: in originated call, in ended call, in the asynchronous intercell handover, etc. The methods of subchannel assignment to the different access typologies can be more than one. Three of them shall be described later on, out of which: a first mode corresponds also to a preferred embodiment of the present invention, while the remaining two correspond to the two other embodiments. The first assignment method is based on the use of a formula that marks at regular intervals the frames of the TDMA multiframe and assigns frame different positions within a marking period to different subchannels, each one associated to a particular access typology. A second subchannel assignment method makes on the contrary a sharing according to access typology of the acknowledgement sequences sent to the Mobile units within a cell to perform the access to the network. This embodiment can be useful in the steps following the access of a Mobile to the network, but also in view of future developments. A third subchannel assignment method combines the two above-mentioned methods to generate synergies.

Brief description of the drawings

The invention together with further objects and advantages thereof, may be understood with reference to the following detailed description of one or more embodiments of the same, taken in conjunction with the accompanying drawings, in which:

- **fig. 1** shows a block diagram of a mobile system of the GSM or DCS type;
- **fig. 2** shows a block diagram of a scenario including a GSM system and a 3G mobile system according to the present invention;
- **fig. 3** shows a hierarchy of sequential frames of the signal transmitted to the interface radio Um of the mobile system GSM of figures 1 and 2;
- **fig. 4** shows a logic channel structure supported by the hierarchy of sequential frames of fig.3;
- **fig. 5** shows two possible organizations of the logic channels of fig.4 within the hierarchy of sequential frames of fig.3;
- **fig. 6** shows a block diagram of a protocol having more hierarchical levels governing the operation of the two mobile radio systems of fig.2;
- **fig. 7** shows a message sequence chart relevant to a protocol of originated call limited to the exchange of messages al the interface radio Um of the mobile system GSM of fig.1;
- **fig. 8** shows a message sequence chart relevant to an ended call protocol limited to the exchange of messages to the interface radio Um of the mobile system GSM of fig.1;
- **fig. 9** shows a message sequence chart relevant to an intercell handover protocol limited to the exchange of messages to the interface radio Um Um of the mobile system GSM of fig.1;
- **fig. 10** shows a message sequence chart relevant to a handshake phase concerning the case of failure of the handover of fig.9;
- **fig. 11** shows a hierarchy of sequential frames of the signal transmitted to the radio interface Uu of the mobile system that includes the present invention;
- **figures 12a, 12b, 12c** show some possible basic frames belonging to the hierarchy of fig.11;
- **fig. 12d** shows the structure of the DwPTS burst, included in the basic frame of fig.12a;
- **fig. 12e** shows the structure of the UpPTS burst included in the basic frame of fig.12a;
- **fig. 12f** shows a general structure of bursts Ts0, ... Ts6 contained in the basic frame of fig.12a;
- **fig. 12g** shows an actual structure of bursts Ts0, ... Ts6 contained in the basic frame of fig.12a;

- **fig. 13** shows a diagram of a criterion employed in the mobile system 3G to share among the different cells the different DwPTS bursts available of fig.12d, together with groups of SCRAMBLING CODEs and groups of midambles that can be referred to the bursts of figures 12f, g;
- **fig. 14** shows a table completing the criterion of fig.13 with the sharing of the available UpPTS bursts of fig.12e;
- **fig. 15** shows a logic channels structure supported by the sequential frame hierarchy of fig.11;
- **fig. 16** shows a partial representation of sequential frames in figures 3 and 11 and their comparison;
- **fig. 17** shows a representation of physical and logic channels relevant to a basic frame of fig.12a;
- **fig. 18** shows a message sequence chart relevant to an originated call protocol limited to the exchange of messages at the interface radio Uu of the 3G mobile system in which the present invention is applied;
- **fig. 19** shows a message sequence chart relevant to an ended call protocol limited to the exchange of messages at the interface radio Uu of the 3G mobile system in which the present invention is applied;
- **fig. 20** shows a Message Sequence Chart relevant to a partial protocol of Intra-system Intercell Handover at the radio interface Uu of the 3G mobile system in which the present invention is applied;
- **figures 21 and 22** similarly show the functional criteria that inspire the process scope of the present invention and of the other embodiments of the same;
- **Appendix APP1** shows a **TABLE A** that includes a very general functional description of level 2 protocols used in GSM and 3G mobile systems of fig.2, and a similar **TABLE B** relevant to level 3 protocols;
- **Appendix APP2** shows some **TABLES 1 through 9** specifying some physical and functional characteristics of the radio interface Uu of the 3G mobile system where the present invention is applied;
- **Appendix APP3** shows some **TABLES 1 to 5** representing application examples of the procedure according to the present invention. More in detail, **TABLES 1 to 4** are referred to a preferred embodiment of the present invention, while **TABLE 5** is referred to a first different embodiment.

Detailed description of some preferred embodiments of the invention

Fig. 11 (the previous ones have already been commented) shows the sequential organization of 7 time intervals, or time slots, in addition to other three special time slots, which shall be described afterwards, within a 3G basic frame indefinitely repeated for the use of a generic carrier among those in use in a cell (much less in number than those used in the GSM because broad band employed). The basic frame of fig.11 includes m time slot UL#0, ..., UL#m (UpLink) coming from the Mobile units MS and n time slot DL#n, ..., DL#0 (DownLink) coming from BTSC (fig.2), being a full-duplexing of TDD type implemented in the 3G system. The set consisting of a carrier, a time slot of utilization of the same and a spreading code forms a physical channel of the Uu interface destined to support an information characterizing the channel from the logic point of view. The sequential frames are organized in more hierarchical levels observed by all the carriers used in the 3G system. The carriers transmitted by a BTS transport reciprocally synchronised frames, thus simplifying the synchronization between adjacent cells. Without setting limits to the present invention, it is convenient to make a general frame synchronization among all the cells of the different clusters, featuring the 3G system as a TD-SCDMA system (Time Division Synchronous Code Division Multiple Access). This said, starting in the figure from bottom to top, we see that the basic frame 3G includes n + m = 7 useful time slots, each one having 0,675 ms duration, in addition to other three special time slots, which are in order: a DwPTS time slot (Downlink Pilot Time Slot) of the duration of 75 μs, a 75 μs guard time GP, and a UpPTS time slot (Uplink Pilot Time Slot) of 125 μs duration. The total duration of the basic frame is 5 ms. 24 basic frames 3G form a 120 ms traffic multiframe. 48 basic frames 3G form a 240 ms control multiframe 3G. 24 × 48 = 1152 basic frames 3G form a superframe 3G of the duration of 5,76 s. The 1152 frames can come from either 48 traffic frames or 24 control frames. 2048 superframes 3G form an iperframe 3G consisting of 2.359.296 frames 3G of the total duration of 3h 16m and 36s. The comparison between figures 3 and 11 shows that the GSM and 3G systems adopt values rather close to the different orders of time division. The hierarchy showed is not binding, for instance it is possible for signalling opportunity to consider two consecutive basic frames of fig.11 as two subframes of a new frame

having double duration, belonging to a multiframe of 72 new frames having 720 ms total duration.

In the 3G basic frame the guard period GP represents the switching point DL/UL. It is used to avoid interference between uplink and downlink transmissions, as well as to absorb the propagation delays between the mobile station and the base station when the first one sends the first signal on the UpPTS channel; at this stage in fact the propagation delay is not yet known. Immediately before the guard period GP there is the special DwPTS time slot and immediately after the UpPTS time slot, both contain synchronization bursts not subject to spreading code, whose function shall be better detailed later on. The remaining time slots contain bursts having a same structure, subject to spreading code, and destined to traffic or signalling. **Figures 12a, 12b and 12c** show different organizations of the basic frame 3G, the first two figures are relevant to a configuration having higher symmetry versus the remaining one. Fig.12a shows the basic frame of fig.11 in a different time position within the multiframe and particularly with starting point in UpPTS, followed by three uplink time slots, indicated in order Ts0, Ts1 and Ts2, then by four downlink time slots Ts3, Ts4, Ts5 and Ts6, and finally by DwPTS and by the guard time GP. Between time slots Ts2 and Ts3, there is the switching point UL/DL (different from the previous one). Fig. 12b shows a completely symmetric situation of three useful time slots in the two directions and the Downlink Td6 time slot available for the signalling, while fig.12c shows a dissymmetric situation with two uplink time slots and four downlink ones more suitable for Internet connections. In fig.12a the duration of the different useful time slots is expressed through a measurement unit called chip, of the duration of 0,78125 μs, equal to the reciprocal of a chiprate = 1,28 Mcps corresponding to the common frequency of a set of N sequence codes used in a useful time slot to perform the spread spectrum according to the CDMA technique. **Fig. 12d** shows that the downlink pilot time slot DwPTS includes a 32-chip guard period GP followed by a 64-chip SYNC sequence. **Fig. 12e** shows that the uplink pilot time slot UpPTS includes a 128-chip SYNC1 sequence followed by a 32-chip guard period GP. And finally **fig. 12f** shows that the common structure of useful time slots Ts0, ..., Ts6 includes two fields having equal length of 352 chips for data, placed respectively before and after a 144-

chip midamble, with a 16 chip guard period GP at closing, for a total of 864 chips.

Each one of the two fields given in fig.12f is modulated by a pre-set number of sequence codes to generate an equal number of radio channels in the band of the spread spectrum, which individually occupy the whole band and represent a same number of so-called resource units RU (Resource Unit) put at disposal of the service and of the signalling; the midamble on its side includes a training sequence used by the BTSC station and by the Mobile units to evaluate the impulse responses of the number of radio channels generated, for the purposes mentioned later on.

With reference to the main burst of fig.12f the following relation applies: $T_s^k = Q_k \times T_c$, where Q_k is a spreading factor SF (Spreading Factor), freely selected among 1, 2, 4, 8, and 16, corresponding to said number N of code sequences; T_s is the duration of a transmitted symbol, and T_c is the fix duration of the chip. From the relation it can be noticed that increasing the spreading factor also the duration of symbols transmitted increases, in other words, the physical channel associated to the main burst increase, but the transmission speeds allowed on the same decrease.

In **Appendix APP2** two tables summarizing the concepts described are given. **Table 1** shows the number of symbols that can be obtained from each Data field of the main burst of fig.12f for the different spreading factor SF of the sequences of CDMA modulation. **Table 2** shows the approximate data transmission speed for the different $RU_{SF1...16}$. From the information supplied we notice that employing a generalised spreading factor equal to 16 in the frame of fig.12a, each one of the 7 useful time slots will carry 54 symbols, to which 10 symbols of UpPTS, 6 DwPTS symbols, 6 equivalent symbols for the GP period shall be summed up, totalling 400 symbols.

Before describing the use of the physical channel it is worth to complete the information featuring them from the radio point of view, starting from the radiofrequency spectrum. The frequency bands available for the 3G system can be allocated around 2 GHz and have variable widths according to the spectrum availability. More in particular, the area of availability is currently included between 1785 and 2220 MHz in non-contiguous bands with width ranging from 15 to 60 MHz, therefore it is possible make the 3G service coexist with that

offered by other systems. **Table 3** of **Appendix APP2** shows the main modulation parameters of the burst in fig.12f. The spreading sequences that modulate data (symbols) are sequences known as Walsh(n) functions. For an assigned spreading factor SF it is possible to select different Walsh functions SF, all orthogonal among them and with free assignment possibility to the Mobile units in a same time slot. In the burst of fig.12f the 16 max possible users that share a time slot could be identified also at midamble level, which is not submitted to spreading code. To this purpose it proved to be useful to obtain (with known methods) a maximum of 16 different versions of the same midamble, cyclically phase shifting the code of a basic periodical sequence for multiples of a minimum shift width. The last significant operation left to consider is the scrambling, that is the multiplication of the elements of each sequence obtained from the spreading process by a scrambling sequence (mixing) typical of the cell. The scrambling confers a pseudo-noise characteristic to the sequence it is applied to. Spreading → scrambling operations can be compared to the application of a spreading code characteristic of the cell. The knowledge of the particular combination of spreading and scrambling codes assigned to the RU enables to transmit the signals to the radio interface Uu and to reconstruct the original signals submitting the signals received to descrambling and despreading inverse operations. A similar approach applies to the midambles.

The next **fig. 13** shows the sharing criterion of the following entities among the different cells of the 3G system: SYNC sequences of the burst DwPTS, scrambling codes, midambles, and SYNC1 sequences of the UpPTS burst (called also signatures). Making reference to fig.13 it can be noticed a table divided into 32 horizontal lines assigned to a same number of SYNC codes denoted DwPTS1, ..., DwPTS32. Assuming the case of a sole carrier per cell the group of 32 SYNC codes indicates also 32 cells, in the contrary instance it would indicate a lower number of cells; the final criterion could be that to foresee as many DwPTS pilots as are the carriers of the 3G system, or of one of its clusters when the need arises. A Scrambling code group consisting of 4 scrambling codes, for a total of 32 groups and 128 codes, assigned in the sequential numeric order as indicated in the figure, is associated to each DwPTSn,. A respective group of 4 midambles is associated to each one of the 32 Scrambling Code Group, for a total of 32 groups and 128 midambles, assigned meeting the same numeric order of the scrambling codes. Out of the 4 midambles, one only is

selected, the SF (Max 16) versions of which, obtained from SF time shift shall be supplied, as said above, when the need arises.

Fig. 14 indicates the sharing criterion among the different cells of the 3G system of the signature sequences SYNC1, each one corresponding to the content of the Uplink Pilot time slot UpPTS. As it can be noticed from the table in the figure, there is a correspondence in the lines with the table of the previous fig.13, in fact also in this case each line represents a carrier (cell) identified by its own DwPTS pilot for a total of 32. A group of 8 different sequences SYNC1 is associated to each downlink pilot DwPTS, for a total of 256, assigned according to the numeric sequence of the figure. As we shall see, a Mobile unit random selects one of the eight sequences SYNC1 associated to a pilot signal DwPTS to have access to the network through the cell identified by that specific pilot signal. A Legend in the figure gives the lengths of the different elements of the two tables.

The different time slots of the basic frame of fig.12a are, in a lesser or higher quantity, subject to beamforming by a resident intelligent antenna, of course in the sole BTSC. The time slots subject to beamforming are associated to a set of complex beamforming constants used in the spatial, or space-time filtering, made by BTSC on the transmission and reception time slots.

The entities introduced up to now, that is: band assigned to the system, frequency of carriers and their distribution among the different cells, structure of the basic frame and of the frame hierarchy, structure of pilot time slots DwPTS, UpPTS and of useful time slots, scrambling codes, midambles and relevant time shifts, number and spreading codes, beamforming constants, as well as other information that shall be described in short on the formation of physical and logic channels, etc., form the frameworks on which the 3G system is based, as conceived by the designers. This information generally characterizes the Level 1 of the protocol and enter as a whole, or in part, the semipermanent data allocated to the different BSCC and BTSC posts dislocated all over the territory. The Mobile performing the roaming, or that is in idle state, is always subjected to the affiliation procedure that associates it to a "Location area" and in particular to a cell, of which it has to know the semipermanent data (frequency, DwPTS, basic Midamble, Scrambling code, UpPTS group). Appropriate system messages fulfil the purpose, which shall be then integrated with subsequent "ASSIGNMENT" messages, to assign the remaining elements (Midamble shift code, spreading

factor and spreading code, beamforming constants, transmission power and time advance) that more properly configure the channel assigned in temporary mode to a connection that involves the radio interface Uu.

The DwPTS, UpPTS and Midamble elements, considering their importance in the 3G system, are better detailed here after. A pilot DwPTS is transmitted by a generic BTSC station without beamforming, or with sector beamforming, and enables the Mobile to perform a Cell Selection procedure when it switches from off to on. To this purpose, the Mobile, in its non volatile memory SIM (Subscriber Identity Module) has stored all the frequencies in use in the 3G system and the corresponding pilot DwPTS, in order that it can start a synchronization downlink scanning to determine the DwPTS pilot received with the highest power, so as to affiliate itself to the relevant cell and proceed to the reading of the broadcasting diffused system information. The Mobile shall thus know the basic midamble in use in the cell and the relevant scrambling code. The discrimination of the DwPTS pilot requires the use of a digital filter whose coefficients are programmed to be coupled to the SYNC sequence examined time by time. During the synchronization a tracing algorithm of the frequency that enables to remove the frequency offset from the signal received can be active. Other functions tasked to the downlink pilot DwPTS, which are only briefly outlined for brevity sake, are the On-air synchronization of adjacent base stations, and the indication to the Mobile units of the starting position and of the interleaving period of a common control primary channel (CCPCH) from which to obtain broadcast diffused system information. This last function can be obtained with different techniques known to those skilled in the sector.

The uplink pilots UpPTS, on the contrary, are initially started by the Mobile units in the Affiliation procedure (Location updating) that follows the Cell Selection phase and then, during first and additional random accesses, to the network in the Cell re-selection procedure and in the asynchronous handover. A mobile randomly selects one of the eight sequences SYNC1 to be sent uplink and starts sending it. The eight sequences of a group are all orthogonal among them, so that they can be simultaneously transmitted by a same number of Mobile units and be discriminated by the base station BTSC without interfering. What said above, applies to all the 256 SYNC1 sequences. The BTSC station that acknowledges a SYNC1 sequence, measures the relevant delay and the power level received and transmits an access timing adjustment message

(Timing Adjustment) to the Mobile on single burst to limit the delay in a sole frame, using an appropriate physical channel P-FACH (described below). The adjusted values shall be used by the Mobile to send the next message. The starting power control and synchronization reduce the total interference on the channels assigned by the network in response to the SYNC1 sequences. The Mobile, on receipt from the network of a co-ordinated response to the transmission of the SYNC1sequence, stops the transmission of the pilot UpPTS. At the assignment of a dedicated channel, the holding of the synchronization and of the correct transmission power is entrusted to the use of the midamble.

A unique basic midamble can generate up to 16 different midambles in a cell, specified by as many coded shift-time values, as are the different versions of the burst that can contemporarily coexist in the time slot, thanks to the maximum spreading value SF. Midambles are subject to the same beamforming and to the same transmission power of the data present in the bursts housing them. The code specifying a midamble is that of a training sequence for the evaluation of the impulse response of the associated radio channel. The functions connected to the midambles are:

- Estimate of the radio channel. It is made both by the Mobile and by BTSC on signals received: since the BTSC station receives phase shifted versions of a same midamble in a time slot, it can profitably employ a joint estimate method, already known in the technique, through which the specific impulsive responses relevant to radio channels engaged by the different Mobile units are obtained in sequence at the output of the correlator, in a sole correlation cycle.
- Measurements for Power Control. Measurements of the Signal/Interference power ratio are made both uplink and downlink to graduate the transmitted power. A mechanism is used based on an internal control loop, it is very fast since it is operated by the first sample of the impulse response, completed by a slower external loop based on quality measurements. Level 1 fields are foreseen in the main burst for the allocation of commands to the transmitters allowing the fast internal loop.
- Holding of the uplink synchronisation. The BTSC station calculates the discrimination instant of the midamble compared to its own time basis, it compares this instant with the previous corrected value, the difference being the new TIMING ADVANCE value to be sent to the mobile for the correction

of the initial transmission instant of the next burst. The accuracy in the uplink transmission is 1/8 of a chip duration. level 1 fields are foreseen in the main burst for the allocation of commands to the transmitters enabling a quick control.

– Correction of the frequency offset. It is a procedure made only by the Mobile units in downlink direction while acknowledging the midamble.

Fig. 12g shows a possible configuration of the main burst of fig.12f in which two L1 Level 1 fields can be seen, placed immediately at the two sides of the midamble. Each one of the two L1 fields is also adjacent to an additional field, jointly destined to a SACCH channel that shall be described afterwards. **Table 4** of **Appendix APP2** shows the meaning, the position in the burst, and the dimensions of L1 fields in fig.12g. The indication of the third column means a spreading factor 16. The table includes three 2-bit fields called PC, SS, and SFL. The fields PC and SS include commands addressed to the transmitter to perform the Power Control (PC) and Synchronization Shift (SS) functions. The fields SFL is a Stealing Flag used in the same way as in the GSM: The first bit of the SFL symbol controls the pair bits of the burst of fig.12g, while the second bit controls odd bits. If the value of a control bit is set at "1", the corresponding pair or odd bits of the burst shall transport signalling of higher Level (FACCH), otherwise the corresponding pair or odd bits of the burst shall transport data, as for instance for the voice. The SFL value is fix for the whole interleaving period along N frames, that depends on the service. The total of 6 bits of fields PC, SS, and SFL are equivalent to 96 chips (6 symbols). The remaining 304 chips for the Data field run out the burst capacity, therefore the four symbols for the SACCH channels must be included in the Data. The following **Tables 5 and 6** show the mapping of the bits of PC and SS fields in the relevant commands, keeping in mind that the minimum step P_{step} is ±1 dB and $1/kT_c$ is 1/8 of the chip time T_c.

Making reference to **Table 7** of **Appendix APP2** the physical channels corresponding to Level 1 elements described up to this moment, are now examined. The same table shows also the mapping of logic channels in the physical channels. It is also worth making a comparison with the corresponding channels of the GSM to highlight the differences at Level 1. The physical channels highlighted in Table 7 are: DPCH (Dedicated Physical CHannel), P-CCPCH (Primary-Common Control Physical CHannel), S-CCPCH

(Secondary-Common Control Physical CHannel), P-RACH (Physical Random Access CHannel), P-FACH (Physical Forward Access CHannel), PDPCH (Packet Data Physical CHannel). Logic channels that can be mapped in the above mentioned physical channel are indicated in the Table with the following names: TCH (Traffic CHannel), SACCH (Slow Associated Control CHannel), FACCH (Fast Associated Control CHannel), BCCH (Broadcast Control CHannel), PCH (Paging Channel), AGCH (Access Grant CHannel), optCH (Optional CHannel), COCH (Common Omnidirectional Channel), RACH (Random Access Channel), FACH (Forward Access Channel 1 burst), PDTCH (Packet Data Traffic Channel), PACCH (Packet Associated Control Channel).

The two peculiar physical channels of the 3G system are undoubtedly the two pilot time slots DwPTS and UpPTS. Out of these, the downlink pilot DwPTS performs, in the new context, functions similar to those of the bursts supporting the SCH and FCCH channels of the GSM, with the exception due to the fact not to carry the frame number TDMA, which should therefore be routed by the broadcast diffused System Information. On the contrary, the uplink pilot UpPTS is unmatched in the GSM, since it is more appropriate to a TDD frame. As we have seen, the Mobile units are compelled to use a signature SYNC1 carried by UpPTS to have a time and power synchronization of the signal that shall be transmitted in the next message, typically on a random channel RACH to request that a dedicated channel is assigned. The time and power synchronization requirement takes place for the first accesses to the network, afterwards, when the network has assigned a dedicated channel to the mobile (UE), provides the midamble; therefore up to that moment the SYNC1 sequence is necessary. The access and synchronization mechanism is therefore different from the GSM, just for the different physical setting out of the 3G system. In the GSM, an uplink time and power synchronization before the assignment of the dedicated channel is not foreseen, since the requirements on the accepted interference degree are less stringent, and also because there is no equivalent uplink of the SYNC1sequences. The correct dynamics shall be seen in the application examples referred to figures 18, 19, and 20. What is necessary to highlight here is that before having access to the RACH channel, as first access, or to a dedicated channel, during the handover, the Mobile continues transmitting the SYNC1 signal up to obtaining an acknowledgement from the network through the

channel P-FACH, and that the sequence can be sent once more (except for the handover) immediately before switching on the dedicated channel.

For what said before, it can be argued how the access mechanism through the signatures SYNC1, due to the iteration of the same and because it comes into play in a first and in a second part of the channel formation procedure, entrains also a wide danger of collision on the physical channel UpPTS; being this a risk attenuated only in part by the fact that the system supplies 8 different SYNC1 orthogonal among them for said channel. However, the measure can be insufficient in a broadband system like the 3G because, contrarily to a narrow band system like the GSM, a considerably lower number of carriers is necessary for each cell (even only one); this means that during the service of the normal telecommunication traffic a considerably higher number of access requests shall be received on a carrier of the 3G system rather than on a GSM carrier. Hence, the conflict probability on the UpPTS channel remains, and it must be neutralized in order not to submit the users to the troublesome inconvenience to withstand more or less long delays in the call set-up. The approach of the present invention is just aimed at regulating the random accesses to the network made through the transmission of sequences SYNC1, in order to reduce in a drastic manner the collision probabilities deriving from the use of the above-mentioned sequences in a UMTS system, like the 3G. It must also be pointed out that the anticollision methods foreseen in the GSM continue to coexist on the RACH channel just as they were foreseen in said Recommendations, and are similarly applicable to the transmission of the SYNC1sequences, also subject to the restrictions imposed by the present invention; through this method the invention is not affected by the above-mentioned methods foreseen in the GSM.

Continuing with the description of the physical channel of **Table 7**, the primary channel P-CCPCH is, for instance, allocated in the downlink time slot 6 (see fig.12a) immediately before the pilot DwPTS. The channel P-CCPCH employs two Resource Units having spreading factor 16. The channel has a fix radiation pattern that can be omnidirectional or subject to a limited beamforming to give the cell a given shape. The lowest shift value of the midamble is always associated to the channel. The primary channel P-CCPCH transports 23 information bytes of higher Level and supplies information on the other common control channels.

The secondary channel S-CCPCH can be freely allocated in all the downlink time slots. The S-CCPCH channel employs two Resource Units having spreading factor 16 and can be subjected to an omnidirectional or adaptive variable beamforming.

The P-RACH random channel can be allocated in one or more uplink time slots, whose number depends on the traffic foreseen, and is used to transport the messages of the Mobile units with the request of assignment of a service channel. The spreading factor is always 16 and can be subjected to an omnidirectional or adaptive variable beamforming. It partly contains Level 1 information.

The P-FACH direct channel can be freely configured in all the downlink time slots. The spreading factor is always 16 and can be subjected to an omnidirectional or adaptive variable beamforming. It partly contains Level 1 information. The channel P-FACH carries the replies of the network to each sequence SYNC1 correctly revealed. The reply message is supplied on a single burst to limit the delay to one single 5 ms basic frame. The network, through the reply attached to the P-FACH channel, gives the mobile station that has sent the sequence SYNC1 an identifier of the acknowledged sequence and of the indications on the correct advance and power level to be used in the transmission of the next message, that shall be very likely a request for a service message on the P-RACH channel. The access to the network through the SYNC1 sequences involves in parallel the fact to have determined a method to assign the Mobile units the channels P-RACH, P-FACH, and P/S-CCPCH (in the present case AGCH) that come into in the immediately next phases. In the definition of this mode we have to face an aspect that is somehow opposite to the collision. In fact, since more than one of the mentioned channels can be configured for each cell, the Mobile unit has the problem to define from which one of these channels it must wait for the reply of the network to a previous sequence SYNC1 (or to a Channel Request, respectively). An answer to the problem just shown, that has the advantage to avoid signalling delays caused by the systematic reading of system information, is given in a recent patent application filed under the name of the same Applicant. The indicated solution essentially consists in creating a link of the following type:

$$\text{SYNC1} \rightarrow \text{P-FACH} \rightarrow \text{P-RACH} \rightarrow \text{AGCH}$$

Equivalent to the link:

SYNC1 → P-FACH → P-RACH → P/S-CCPCH

Submitted to the following restrictions:

- The mapping must associate each one of the 8 SYNC1 sequences to a channel P-FACH. Each P-FACH must be the destination of one SYNC1 at least.
- The mapping from P-FACH to P-RACH must create an association with a P-RACH that has been configured. Each configured P-RACH must be the destination of at least one P-FACH.
- The mapping from P-FACH to AGCH must create an association with a P/S-CCPCH that has been configured. The channel P/S-CCPCH shall carry an AGCH. Each configured AGCH shall represent the destination of the mapping of at least a P-RACH.

The information defining the different links foreseen is included among the broadcast diffused system information, and therefore a link is known by the Mobile and by the network even before establishing a connection. **Table 8** of **Appendix APP2** gives an example of such association of groups of sequences SYNC1 and channels P-FACH. As it can be noticed from the table, increasing the number of time slots used by the channels P-FACH, the SYNC1 groups consequently increase and the number of elements in the single groups averagedly decreases. The fact to have established a link like the prospected one enables the Mobile to have a reply from the network, enabling to profitably make the appropriate corrections.

The physical dedicated control channel DPCH corresponds in **fig. 12g** to the two fields L1 placed at the two ends of the midamble and at the adjacent fields reserved to SACCH channels. These are bi-directional channels subject to beamforming. The burst structure of fig.12g is not adequate to the use during the access to the network, characterised by an intensive use of PC and SS commands addressed to the different Mobile units, this task is performed by the physical channel P-FACH that employs the whole burst.

The channel PDPCH has the same structure of DPCH dedicated channels, the meaning of Level 1 fields obviously changes.

We shall now describe the logic channels mapped in physical channels of **TABLE 7,** they are also called transport channels because they deliver to the Physical level of the radio interface a block supplied by the upper Level of the

protocol. From the functional point of view, logic channels of Table 7 are grouped as indicated in **Fig. 14.** Making reference to the figure, we can notice the following three main groups: TRAFFIC CHANNELS, CONTROL CHANNELS, and PACKET DATA CHANNELS. The group of CONTROL CHANNELS includes the following channel types: BROADCAST CHANNEL, COMMON CONTROL CHANNEL, and DEDICATED CONTROL CHANNELS. The break down can be read in the table where TCH/F is a TCH Full-rate, TCH/H is a TCH Half-rate, and the optional channels are indicated with NCH (Notification CHannel), and CBCH (Cell Broadcast CHannel). As it can be noticed, all the channels referred to the BROADCAST CHANNEL are classified also as omnidirectional (COCH). There is some similarity with the GSM channels, however correspondence is not correct and where a difference exists at functional level, and in general it differs at physical and mapping level. The following description includes the functional aspect and the mapping methods and starts from the dedicated channels:

- TCH (Traffic CHannels). These are bi-directional channels carrying the coded voice or data generated by the user in circuit switching mode. Two types are available: full-rate TCH/F and half-rate TCH/H. The whole payload is mapped in the physical channel DPCH in the portion not used for Level 1 signalling and SACCH channels. It is possible to map an RU_{SF8} or one, or two, RU_{SF16}. For high data rates, TCH channels can be combined. They are subject to beamforming.
- FACCH (Fast Associated Control CHannel). It is associated to traffic channels TCH in bit stealing mode, as already said. It is mapped allocating 23 bytes in one or two interleaved frames. It is used by the network and the Mobile units to transfer some urgent and important information, like that of the handover. This channel is also called main DCCH (Dedicated Control Channel) since it forms the skeleton of the so-called Main Signalling Link, that is a bi-directional Radio Link, unique for RR connection (Radio Resource) but that can temporarily be even double for the handover, made of at least one uplink RU and one downlink RU carrying a FACCH channel. SACCH is part of the Main Signalling Link and a TCH channel can also form part.
- SACCH (Slow Associated Control CHannel). It is associated to the traffic channels TCH and is used by the network and Mobile units to transfer some

non-urgent and non-critical information such as measurement data. It is mapped allocating 23 bytes in 24 no. 5-ms-frames and there are four symbols for the SACCH channel in each TCH burst. **Fig. 16** compares the GSM 26-frames traffic multiframe in 120 ms with the 24-frame 3G multiframe in 120 ms. In the upper line, six 260-bit blocks at the output of the voice encoder common to the two systems are mapped. As it can be noticed, in the GSM there are two unused TCH frames that can be put at disposal of SACCH channels. In particular, the 26[th] frame is used to perform measurements on close BTS stations without voice or data loss. In the 3G system this kind of frames is not present, therefore the channels SACCH must be mapped within each TCH channel.

- BCCH (Broadcast Control CHannel). Diffuses downlink in broadcast mode the system information within a cell. The channel BCCH is mapped in two RU_{SF16} of the physical channel P-CCPCH. The channel BCCH shares the spaced frames of the physical channel together with the PCH channel or other common control channels. The sequence modulation of the pilot DwPTS indicates the starting of an interleaving period of the channel P-CCPCH containing the BCH channel (Broadcast Channel). The layout of the physical channel P-CCPCH is signalled in the system information. **Table 9** in **Appendix APP2** gives an example of multiplexing of common control channels BCCH and PCH in the multiframe of 48 control frames. To this purpose, the multiframe is subdivided into spaced blocks, four basic frames long. A unique SYSTEM INFORMATION message is transmitted on a BCCH channel configurable at a pre-set position versus the System Frame Number SFN.
- PCH (Paging CHannel). It transmits downlink the paging messages to the Mobile units. It can have a radiation pattern either omnidirectional or subject to beamforming. Its mapping in P-CCPCH or S-CCPCH is indicated in the system information carried by BCCH.
- AGCH (Access Grant CHannel). It is used downlink by the network to send a Mobile an answer to a previous Channel Request message sent by a Mobile on the P-RACH channel, whenever the message has been correctly revealed and accepted. Notice the difference from P-FACH that carries the answers to SYNC1.

- CBCH (Cell Broadcast Channel). Is a channel used for the SMSCB service (Short Message Service Cell Broadcast).
- NCH (Notification Channel). It is a channel used to notify the Mobile Units calls of the conference type.
- RACH (Random Access CHannel). It is used by the Mobile units to transmit the request messages of a service channel. Its mapping in P-CCPCH is indicated in the system information carried by BCCH.
- FACH (Forward Access CHannel). It is used by the network to transmit the Power Control (PC) and Synchronization Shift (SS) commands to the Mobile units as immediate reaction to the transmission of a SYNC1.
- PDTCH (Packet Data Traffic CHannel). They carry packet switching data.
- PACCH (Packet Associated Control CHannel). They carry signalling associated to packet switching data.

In the 3G system it is not possible to follow the same approach used by the GSM system to make the dimensioning and allocation of logic channels. In the GSM each downlink time slot is coupled to an uplink time slot, therefore it is supplied a natural connection among all the logic channels sharing the combination of channels of a time slot multiframe. This fact is employed in the GSM to associate a PCH channel to a RACH channel and to associate a RACH with an AGCH. If the combination of channels is present on more than one time slot within a cell there is a method to distribute the Mobile units among the channels to the purpose of sharing the load. In the 3G system there is not a natural connection of the highlighted type, consequently a similar connection among the control channels shall be built through its definition. The broadcast diffused system information shall contain a trace of the agreed definition. The control channels considered, represent an allocation set called CCHset (Control CHannel Set). In the 3G system more than one CCHset can be configured. **Fig. 17** shows a possible layout of a CCHset and of a P-FACH channel within a 3G 5 ms basic frame.

Figures 18, 19 and 20 are Message Sequence Charts showing some application examples of all the notions supplied up to now on the 3G system. The Charts are referred to a same number of procedures employing the means and teachings featuring the present invention. The procedures described are the more significant ones among those foreseen at the interface Um. To the

purposes of the invention, the criterion according to which it is called in question by the following messages, applies: BCCH, HANDOVER COMMAND, IMMEDIATE ASSIGNMENT, UPLINK FREE. The last message (not discussed up to now) is sent by the Mobile in the uplink access procedure relating to a VGCS channel (Voice Group Call Service). Through this message MS aligns the synchronism and the power level to start the immediate assignment procedure that shall be described in short. The message UPLINK FREE is preceded by the transmission of the SYNC1 burst that has as immediate reaction by the base station BTSC the downlink transmission of a PHYSICAL INFORMATION message.

Figures 18 and 19 are respectively referred to the procedures of originated call from the Mobile MS and of ended call towards the Mobile MS. In the Chart, all the entities (BTSC, BSCC; MSC) different from the Mobile MS are indicated with the generic term NETWORK, maintaining the possibility to specify the physical or protocol entity involved. The procedures of the two figures are similar and both originate from an Idle state of the Mobile in which it monitors the Paging messages sent by the network on PCH channels. Entering in the first one rather that in the second one depends on the fact that the Mobile decides on self-initiative to request a channel rather than being ordered to do it by the network. The phases coming after entering one or the other operation phase belong to an IMMEDIATE ASSIGNMENT procedure, whose purpose is that to establish a RR connection (Radio Resource) between the mobile station and the network. From this point on, the description applies to both the figures, assuming that before starting the IMMEDIATE ASSIGNMENT procedure, the Mobile has acquired the following information from the so-called System Information contained in the P/S-CCPCH channel:

- The map between the SYNC1 signatures and P-FACH channels; between the channels P-FACH and P-RACH channels; between the P-RACH channels and AGCH channels configured in P/S-CCPCH;
- The uplink interference level on the uplink pilot UpPTS;
- The level of transmission power of the P-CCPCH channel;
- The System Frame Number **SFN**;
- The Following control parameters of the random access:

1. The step PSTEP to increase the power level at each retransmission of SYNC1;
2. The values of some parameters· globally indicated as "access parameters" that, according to the teachings of the present invention, and of the other embodiments of the same, enable to schedule access subchannels $UpPTS_{SUBCH}$ to which send the SYNC1bursts;
3. The maximum value "M" for the retransmission of the SYNC1burst;
4. The number of frames "Tx-integer" between retransmission of the two SYNC1bursts;
5. The values of control access parameters "CELL_BAR_ACCESS";
6. The allowed access classes "AC" and "EC".

This said, the IMMEDIATE ASSIGNMENT procedure can be started only by the RR entity of the Mobile. The initialisation is triggered by a request of sublevel MM or by the LLC level (Low Layer Compatibility) to enter the dedicated mode or by the RR entity in reply to a PAGING REQUEST message. At such a request: if the access to the network is allowed, the RR entity of the Mobile starts the immediate assignment procedure that shall be defined, otherwise it rejects the request. The request from sublevel MM to establish a RR connection specifies an "establishment cause". Likewise, the request from the RR entity to establish a RR connection in reply to a PAGING REQUEST 1, 2 or 3 message, specifies one the causes of establishment "answer to paging".

All the Mobile Units stations with a SIM card inserted are members of one of the 10 access classes numbered 0 to 9. The access class is stored in the SIM. In addition, the Mobile Units stations can be members of one of the 5 access special classes (11 to 15) also stored in the SIM card. The System Information messages on the BCCH channel broadcast diffuse the list of the access authorized classes, of special ones, and if emergency calls are allowed in the cell to all the Mobile units or only to the members of authorized special access classes. If the "establishment cause" for the request of a sublevel MM is not an "emergency call", access to the network is granted only if the Mobile is member of at least one authorized access class, or of an authorised access special class. On the contrary, in case the "establishment cause" is an emergency call, the access to the network is allowed if and only if emergency calls are allowed to all the Mobile units of the cell, or if the Mobile is member of at least an authorised special access class.

The previous points 3 to 6 relevant to parameters "M" and "Tx-integer", together with what said on the access classes, represent the mechanisms implemented in the GSM to limit the collisions on the RACH channel. They essentially consist in expanding in time the repetition of the random access attempts made by a mobile, limiting the same in number in order not to overload the channel. When this mechanism proves to be insufficient, like for instance in peak traffic moments, the mechanism of the access classes that selectively and temporarily inhibits the access to the network to groups of users comes into play. As we shall see later on, these regulation mechanisms of the random accesses are rather different from those implemented by the present invention, that result being complementary to the same. Once the access requirements are met, the RRM protocol entity of the Mobile starts the IMMEDIATE ASSIGNMENT procedure scheduling in an appropriate way the transmission of a SYNC1 burst on the physical channel UpPTS, consequently leaving the idle mode (in particular ignoring paging messages). The Mobile shall then send M + 1 burst SYNC1 on the UpPTS channel in order that:

- The SYNC1 bursts shall be selectively sent matching an access subchannel **UpPTS**$_{\mathbf{SUBCH}}$ determined through the access parameters foreseen by the present invention;
- The number of frames between the starting of the immediate assignment procedure and the transmission of the first burst SYNC1 (excluding the frame containing the burst itself) is a number randomly showing for each new starting of the immediate assignment procedure with even distribution probability in set {0, 1, ..., Tx-integer 8 – 1};
- The number of frames between two successive transmissions of SYNC1 shall be the minimum allowed value in compliance with the scheduling made according to a preferred embodiment.

After having sent the first burst SYNC1, the Mobile starts monitoring the corresponding P-FACH channel to reveal the PHYSICAL INFORMATION message. This message shall contain the reference number of the signature used by MS, the number of the control frame CFN, the relevant number of frames from the one carrying the acknowledged burst SYNC1 (acknowledged), the interference Level on the corresponding P-RACH, the Timing advance and the Power level correlated to the acknowledged burst SYNC1. The PHYSICAL

INFORMATION message is waited for within 4 frames from SYNC1 transmission. In case no valid reply is revealed, the above mentioned procedure must be repeated up to M times or up to revealing of the message waited for by the network.

Having sent M + 1 SYNC1 bursts with no valid answer from the network, the immediate assignment procedure is aborted; if said procedure was triggered by a request of the MM sublevel, these are notified of the failure of the random access. The Mobile, as soon as the waited message is revealed, starts a timer T3126 and sends a CHANNEL REQUEST message on the corresponding P-RACH channel with the correct values of synchronization and power level parameters. The CHANNEL REQUEST message shall contain at least the following parameters:

- An "establishment cause" corresponding to the "establishment cause" given by the sublevel MM, or corresponding to a cause "reply to paging" data given by the RR entity in reply to the PAGING REQUEST message including the information on the channel needs;
- A random reference randomly selected from an even distribution probability for any new transmission;
- the Time Advance and the Power Level employed by the User Equipment (UE) to have access to the network;
- The interference level on that Time slot signalled in broadcast by the network.

The Mobile, after transmission of the CHANNEL REQUEST message, starts monitoring the corresponding P/S-CCPCH to detect the IMMEDIATE ASSIGNMENT message waiting for it on the AGCH configured channel. When the count of timer T3126 expires, the procedure of immediate assignment is aborted and the sublevel MM is notified of the failures of the random access, in the case MM were responsible for the actuation of the access procedure.

The network can allocate a channel dedicated to the mobile sending it an IMMEDIATE ASSIGNMENT message in no-acknowledgement mode on the AGCH configured channel. A Timer T3101 is then started on the network side. The IMMEDIATE ASSIGNMENT message shall contain:

- The description of the assigned radio RU resource, the channelling code, the frequency and the Time slot; the information field of the CHANNEL REQUEST message and the frame number of the frame in which the above-

mentioned message has been received; the starting timing advance and the power level the MS shall use for the next transmission on the dedicated channel; the access parameters identifying the access subchannels $UpPTS_{SUBCH}$ according to the present invention, and the signature reference number SYNC1; optionally, the indication of a starting time indicated by the frame number.

The Mobile, on receipt of an IMMEDIATE ASSIGNMENT message corresponding to its CHANNEL REQUEST message, stops the Timer T3126 and at the next frame versus the scheduled one sends a SYNC1 burst assigned by the network on the physical channel UpPTS.

The network replies to the burst SYNC1 at the frame immediately after, sending a PHYSICAL INFORMATION message enabling an additional finishing of the synchronisation and of the power level Mobile side. At the same time the Mobile shall switch on the channel assigned in reception mode, setting the channel mode for the sole signalling; the transmission mode shall be enabled the frame after the burst SYNC1 has been heard, even in the case an invalid PHYSICAL INFORMATION message has been received by the network. The Mobile establishes then the main signalling link on a dedicated channel DPCH with a SABM (Set Asynchronous Balanced Mode) containing an information field. In case the Mobile receives an IMMEDIATE ASSIGNMENT message containing only the description of a channel to be used after the starting time, it shall wait until the starting time before having access to the channel. If the starting time has already elapsed, the Mobile will have access to the network as immediate reaction to the message reception. In this case, it is recommended that the Mobile sends the burst SYNC1 just in time before switching the assigned channel, in order that its synchronism and the power level are updated as much as possible.

If no channel is available for the assignment, the network sends the Mobile an IMMEDIATE ASSIGNMENT REJECT message in unacknowledged mode on the corresponding P/S-CCPCH channel. This message contains the reference to the request and a wait condition. The Mobile, on reception of an IMMEDIATE ASSIGNMENT REJECT message corresponding to its CHANNEL REQUEST message, shall start a Timer T3122 with the value indicated of IE (Information Element "Wait Indication" referred to the cell in which it has been received), and shall monitor on the corresponding P/S-CCPCH channel until the count of timer

T3126 expires. During this time, additional IMMEDIATE ASSIGNMENT REJECT messages are ignored, but any immediate assignment corresponding to its CHANNEL REQUEST message, makes the mobile perform the procedure described in the following steps. If no IMMEDIATE ASSIGNMENT message is received, the Mobile returns in idle mode CCCH to monitor its paging channels. As an option the Mobile can return in idle mode CCCH as soon as it has received an answer from the network to its CHANNEL REQUEST message. The Mobile is not permitted to make a new attempt in the same cell to establish a RR connection without emergency until the count of the Timer T3122 expires. The Mobile, provided that an IMMEDIATE ASSIGNMENT REJECT is not received for an emergency RR connection attempt, can try to enter in dedicated mode for an emergency call the same cell before the count of the Timer T3122 is expired. The Mobile in "packet idle mode" (limited to the Mobile units supporting the GPRS) can start a packet access in the same cell before the count of the Timer T3122 is expired. After expiration of T3122, no CHANNEL REQUEST message shall be sent as reply to a page, up to reception of a PAGING REQUEST message for the Mobile.

The IMMEDIATE ASSIGNMENT procedure is ended on the network side when the main signalling link is established. The Mobile sends the UPLINK ACCESS message (UA), the network stops the Timer T3101 and the sublevel MM of the network side is informed that the RR entity entered the dedicated mode. Before qualifying the assignment and use methods of the access parameter identifying the access subchannels $UpPTS_{SUBCH}$, it is worth describing in short the Intra-System Handover procedure to the sole purpose of highlighting the aspects concerning the present invention.

Making reference to **fig. 20**, the network starts an Intra-system Intercell handover procedure towards the Mobile unit, sending it a HANDOVER COMMAND message on the Main Signalling Link DCCH of the old cell and starting the count of a Timer T3103. For this, it is supposed that the preliminary functions to the handover have been accomplished, including the LAPDm protocol ones consisting in the initialization of a data connection in the new cell for the service SAPI = 0 (Service Access Point Identifier that identifies the signalling).

The Mobile, after receipt of the HANDOVER COMMAND message, starts releasing the old connections to the different Levels of the protocol, disconnects

the physical channel, directs the switching towards the channels assigned in the new cell and starts establishing the new connections at lower Levels (this includes the enabling of channels, their connection and the establishment of data connections). The HANDOVER COMMAND message includes (in summary):

- The characteristics of the new channels, including the correct indication of the AGCH channels and of FACCH and SACCH channels that shall be used for the multiresource configuration and, optionally, the power level to transmit on the new channels.
- The characteristics of the new cell that are necessary to successfully communicate, including the data that enable the Mobile to use the pre-knowledge on synchronization it acquires from the measurement procedure (for instance, the cell scrambling code + the frequency and power level of the channel PCCPCH/DwPTS). The power level of the channel PCCPCH/DwPTS shall be used by the Mobile for the initial power on, on the new channel(s).
- A Power command (optional). The power level defined in this Power command shall be used by the Mobile for the initial power on, on the new channel(s) and shall not affect the power used on the old channel(s).
- An indication of the procedure to use to enable the new physical channels.
- A handover reference used in the different protocol Levels.
- Some parameters for the access to a dedicated channel due to handover, among which: the identifier of the group of SYNC1 sequences in use in the new cell, the access parameters identifying the access subchannels $UpPTS_{SUBCH}$ in the new cell, and the description of P-FACH channels.
- A timing advance value to be used in the new cell (optional: used for synchronized cells).
- A real time difference that the Mobile shall use to calculate the timing advance to apply in the new cell (optional: used for synchronized cells).
- A ciphering mode to apply to the new channel (optional). If this information is not present, the ciphering mode is the same of that used on the previous channel. In both the cases the ciphering key shall not be changed. The HANDOVER COMMAND message shall not include an IE of ciphering mode indicating "start ciphering", unless a CIPHERING MODE COMMAND message has been previously transmitted; in the example shown, if a similar

HANDOVER COMMAND message is received, it shall be considered wrong and a HANDOVER FAILURE message shall be immediately returned due to "Unspecified protocol Error", and no further action shall be undertaken.

The following steps up to one in which the Mobile sends a HANDOVER ACCESS message in the new cell, are made in the case of Handover Intercell among non synchronised cells, but could be made also for synchronous cells to optimize access time and power parameters. The network in the HANDOVER COMMAND message signals which one of the two procedures must be enabled.

The Mobile, after receipt of the HANDOVER COMMAND message, starts sending the sequence SYNC1 on the UpPTS channel of the cell indicated, in the level 1 frames are reserved to the purpose, according to the criteria of the present invention. The Mobile starts a Timer T3124 setting the starting point of the count at the time slot where the burst SYNC1 has been sent for the first time to a UpPTS. If the HANDOVER COMMAND message indicates more than a sequence SYNC1 allowed, the Mobile randomly selects among the allowed SYNC1 sequences.

The network obtains the necessary characteristics RF from the SYNC1 burst, and sends a PHYSICAL INFORMATION message on the relevant P-FACH channel in "unacknowledged" mode. The Mobile, after having sent the first burst SYNC1, starts monitoring the P-FACH channel indicated to reveal the PHYSICAL INFORMATION message. This message shall include the reference number of the signature used by the Mobile, a frame number relevant (see note) to that in which the SYNC1 acknowledged burst (acknowledged) has been received, the interference level on the corresponding P-RACH, and the Timing advance. The PHYSICAL INFORMATION message is waited for within 4 frames from the transmission of SYNC1. In case no valid response is revealed, the above mentioned procedure shall be repeated until the count of Timer T3124 expires.

Note: the above-mentioned relative frame number has no connection with the absolute frame number in force in the cell (still unknown to the Mobile in this phase of the procedure), but on the contrary it is a Level 1 information that indicates to the Mobile a distance between the reception frame of the PHYSICAL INFORMATION and the emission frame of the SYNC1 which the same refers to. This distance helps the Mobile to understand if the reply of the network is addressed to it.

When the Mobile receives a PHYSICAL INFORMATION message it stops sending the SYNC1 bursts and starts recurrently sending the HANDOVER ACCESS message in successive frames on the Main Signalling Link DCCH. This message is sent on single burst in no-ciphering mode. Ciphering/deciphering cannot start because the Mobile does not know yet the frame number SFN of the new channel in the destination cell. Just from the reception of the PHYSICAL INFORMATION the handover procedure is no more significant to the purposes of the present invention but, for completeness, it is worth going on in the description, highlighting a technical problem due to the missed knowledge of the frame number SFN concerning the dedicated channel in the new cell. The problem arises due to the difference at Level 1 of the downlink synchronization mechanism of the 3G system compared to the GSM. As already said, the downlink pilot DwPTS does not include the frame number SFN, which shall be initially acquired by the P-CCPCH channel. Therefore the Mobile after having sent the HANDOVER ACCESS message, if not otherwise specified, starts monitoring the System Information to acquire the frame number SFN. The HANDOVER ACCESS message contains the following parameters:

- A handover reference received in the HANDOVER COMMAND message;
- The time advance and the power level used by the UE to have access to the network.

When the Mobile can read the information on the frame number it stops the Timer T3124, it stops sending the HANDOVER ACCESS message, it enables the physical channel in transmission and reception mode, using the coding/decoding scheme requested by the service, and if necessary it connects the channels. When applicable the ciphering/deciphering immediately starts.

When the connections at the lower Level have been successfully established the Mobile returns a HANDOVER COMPLETE message specifying the cause of " normal event " to the network on the DCCH link. The transmission of this message, Mobile unit side, and its reception, network side, enables the summary of the transmission of signalling messages of Levels different from the RR management ones.

When the network receives the HANDOVER COMPLETE message, it stops the Timer T3103 and releases the old channels together with the signatures possibly destined to the handover procedure. Irregular cases can occur particularly in the synchronous handover, in which the Mobile transmits a

HANDOVER FAILURE message to the network with the specified cause, for instance, "handover impossible, timing advance out of range".

The description of the main procedures that foresee the use of sequences SYNC1 by the Mobile units to have access to the network ends here. The procedures described are those relating to Cell Selection (first access), Cell Re-selection, and asynchronous handover. We have exhaustively said that the accesses on the UpPTS channel are intrinsically subject to collisions. The solution given by the present invention to prevent collisions is to define access classes to the network through the scheduling of different subchannels $UpPTS_{SUBCH}$ for the transmission of signatures SYNC1 at disposal of the Mobile. According to a preferred embodiment of the present invention, the network schedules a subchannel $UpPTS_{SUBCH}$ N° defining the frame numbers in which the transmission of a signature randomly selected by the Mobile among those of the availability group is allowed. Two parameters P1 and P2 are foreseen to this purpose. The Mobile wanting to have access to the network, sends a signature sequence SYNC1 on the channel UpPTS when the system frame number SFN satisfies one of the following laws:

$$\text{SFN module } [P1] = P2 \qquad (1)$$

$$\text{SFN module } [P1] \neq P2 \qquad (2)$$

The indication of which one of the two laws has to be selected, as well as the values of parameters P1 and P2 are information elements forming part of the above mentioned access parameters included in the following relevant messages: BCCH, HANDOVER COMMAND, IMMEDIATE ASSIGNMENT, UPLINK FREE. Each signature SYNC1 transmitted, or retransmitted, on the subchannel UpPTS is randomly selected among the values of the signatures supported by the downlink carrier synchronised by the Mobile, this involving the serving cell or the new cell in case of handover. As for the first access to the UpPTS channel in the state of Cell re-selection (that is before the IMMEDIATE ASSIGNMENT message is revealed or before entering in transmission group mode), the Mobile can read the scheduling of channels UpPTS and the indication for the selection of law (1) or (2) from the BCCH channel, while for the subsequent accesses in the Cell re-selection state, the Mobile can receive the necessary information from the remaining HANDOVER COMMAND messages, IMMEDIATE ASSIGNMENT, UPLINK FREE.

The network (BSCC, NE) shall nullify the assignment of a subchannel UpPTS to a specific Mobile as soon as the relevant procedure: IMMEDIATE ASSIGNMENT, HANDOVER or UPLINK REPLY is completed, either successfully or not. More in particular, it must be pointed out that the network in this phase of the access procedure does not know (or does not want to know) the Mobile through its identifier IMSI, but indirectly through the signature SYNC1 that it sends on the subchannel $UpPTS_{SUBCH}$ N° scheduled to the purpose. In theory, there still could be collision probability on the subchannel, and then the collided Mobile units could not be distinguished by the network, but this probability is no doubt lower than the case of missing scheduling. In lack of a scheduling of subchannels like that made according to the criteria of the present invention, there would be a signature overcrowding on the UpPTS channel and consequent increase of the collision probability for the dispute of the channel. In a situation like this the damage for the service would only be limited by the usual anticollision mechanisms foreseen in the GSM, that have however the drawback to increase the overload of the network, due to repeated access attempts, if not even that to temporarily exclude whole service classes from the traffic. It is then evident that maintaining the anticollision mechanisms of the GSM in the 3G system has to be considered complementary in extreme load situations.

Tables 1 to **4** included in **Appendix APP3** will help understanding the realization aspects of the preferred embodiment of the invention in some practical cases in which, for sake of simplicity, law (1) only is considered. **Table 1** shows a general view of all the possible subchannels $UpPTS_{SUBCH}$ shared according to access type, due to the fact that the access belongs to the first or to the second part of the assignment procedure of the channel, and in the frame of this last subdivision, due to the fact that the access is controlled by the Mobile or by the network. **Tables 2, 3** and **4** show the cyclic nature of law (1), or (2), deriving from the application of the module[P1] function to the independent variable SFN, evenly increasing in time with unit increase within the system multiframe (iperframe). The granulation in the definition of subchannels increases the relevant number and therefore the period of intervals deriving from the application of law (1) or (2). This involves a negligible delay in access, largely compensated by the decrease of the collision probability, aided by reduction of access attempts on the single subchannel. The laws (1) and (2) have a very simple and easy-to-use mathematical expression, however a similar result could be reached applying

other expressions capable of mathematically countermarking (mark) a basic frame within the hierarchical multiframe (iperframe), with the possibility to separately control the repetition periodicity and period starting phase. Applying the law (1) and (2) a subchannel $UpPTS_{SUBCH}$ consists of the group of equal period and equal phase marked frames. The meaning of parameters P1 and P2 is the following: P1 gives the total number of the possible subchannels, while P2 corresponds to the identifier $UpPTS_{SUBCH}$ N° of a subchannel.

Table 2 shows a scheduling of the $UpPTS_{SUBCH}$ subchannels that identically recurs every 4 frames, being P1 = 4, in which 50% of the subchannels are destined to the handovers and the other 50% to the random access. In this case, it results from table 1 that 25% of subchannels $UpPTS_{SUBCH}$ is destined to the transmission of a signature SYNC1 controlled by the Mobile units and 75% by the network. **Table 3** shows a different scheduling of subchannels $UpPTS_{SUBCH}$ UpPTS in which the previous value of P1 = 4 is maintained, while 25% of subchannels are for the handovers and 75% for the other random access procedures. In this second case, notwithstanding the different scheduling versus Table 2, the sharing of subchannels among the Mobile units and the network results the same from the point of view of the responsible for the command of transmission of signatures SYNC1. **Table 4** shows a scheduling in which the number of subchannels $UpPTS_{SUBCH}$ is increased compared to the two previous tables, and therefore the value of P1 that is selected equal to eight, to distinguish between random access in call originated from the Mobile (m.o.c.) or ended towards the Mobile (m.t.c.). In the group of the eight subchannels that repeats, the distribution percentage of UpPTS subchannels between handover and the other random access procedures are similarly of 50%. In this third case only 12,5% of subchannels is destined to the access controlled by the Mobile units while the remaining 87,5% is at disposal of the network. The subchannels of Table 4 have the following identifiers $UpPTS_{SUBCH}$ N°: handover 0/2/4/6; RA1# (m.o.c.) 1; RA1# (m.t.c.) 5; RA2# (m.o.c. + m.t.c.) 3, 7.

The previous tables show that it is possible to select different combinations of parameters P1 and P2 to control the random accesses made by the Mobile units on the channel UpPTS in the different procedures foreseen at the Um radio interface. The operator who configures the system can take advantage from the invention for a correct planning of resources against the expected traffic. An

interesting feature of subchannels obtained as above, is that not to necessarily require the knowledge of the absolute system frame number SFN within the iperframe. In fact, it is sufficient to know a reduced frame number FSN' whose numbering starts coinciding with the starting frame of a periodic signalling in the multiframe and repeats with the same periodicity. Since the interleaving period of said signalling corresponds to the needs of the channel P-CCPCH. Table 9 shows an example where the multiframe made of 48 control frames is subdivided into 12 blocks of fours frames each, each block being assigned to a BCCH or PCH channel for the transport of system and paging information. In this case the starting frame of the signalling blocks has a four frame interleaving period. As already said, the need for said starting frame of a block is signalled with known techniques employing an information purposely impressed in the burst of the downlink pilot signal DwPTS. Considering then the initial frame of an interleaving period of the system signalling, coinciding with the initial frame of the repetition period for the calculation of shared access subchannels, the necessary and sufficient condition for which in lack of knowledge of the absolute frame number SFN it is possible to replace the absolute frame number SFN by the reduced number SFN' in expressions (1) or (2), is that the values of the two access parameters P1, P2 are such to identify a subchannel in the multiframe inside or coinciding with said interleaving period of the signalling. In the case of the stated formula the condition is given by P1 ≤ interleaving period of the signalling. The compliance with such a condition enables the Mobile to keep up the pace with the temporal evolution of the needs of a message carried by those channels employing the partition in blocks of the control multiframe. What just said on the absolute reduced frame number SFN' has a less general value compared to the use of the absolute frame number SFN, to which different system and signalling functions are tied, however in some cases the utility of the reduced number SFN' is evident, such as for instance in the case of intercell handover of the asynchronous type. In this case in fact the Mobile has the need to synchronise itself at the frame timing occurring in the new cell, and to this purpose it shall start sending the SYNC1 to the subchannels foreseen for the handover. These subchannels cannot be calculated at first by the Mobile due to the lack of knowledge of the absolute frame number SFN. The wait for decoding of such an information could reveal to be too long, therefore the Mobile can, as an alternative, interrogate the downlink pilot DwPTS and get much more quickly the

information on the starting of the interleaving period of the signalling, which is equivalent to acquire the reduced frame number SFN' with which to calculate the handover subchannels through the formula (1) or (2) waiting for reading the absolute frame number SFN.

It is now described a first different embodiment of the procedure of the invention, for the description of which reference can be made to **APPENDIX APP3, TABLE 5.** Applying the other embodiment, the subchannels, are now generated, not through the calculation of a mathematical expression, but through an appropriate sharing of signature sequences SYNC1 associated as a whole to a carrier in use in the cell. Through the sharing, the SYNC1 at disposal of a Mobile are subdivided into a given number of separate sub-sets, possibly of a single element, each sub-set being associated to a an access typology. **TABLE 5** shows a possible partition in which the eight SYNC1 available are assigned 50% to the handover and the remaining 50% to the other access typologies indicated in the first column. Eight subchannels are indicated In Table 5 through the same identifiers $UpPTS_{SUBCH}$ N° already used in Table 4 to indicate equal access typologies. Each identifier $UpPTS_{SUBCH}$ N° in Table 5 indicates a subchannel consisting of a relevant signature sub-set. The particular composition of a sub-set, that is, the identifiers of the signatures included in the sub-set, is indicated by an information element SYNC1-RIP. In the formation of the subsystems, an identifier $SYNC1_N$ that identifies a sequence SYNC1 within the group of 8 signatures at disposal of the carrier, is freely selected among those not yet assigned; this freedom is due to the fact that there is no particular reason to select a sequence signature rather than another one. This said, and whenever more than one signature is foreseen in a signature sub-set associated to the subchannel $UpPTS_{SUBCH}$ selected, the Mobile units employing that subchannel randomly select a signature among those belonging to the sub-set. In the case of the first embodiment, the information corresponding to the above mentioned access parameters will include the information elements SYNC1-RIP and $UpPTS_{SUBCH}$ N°; it shall be transferred through the same channels and availing of the same messages already highlighted with reference to the preferred embodiment of the invention. In the case of the first different embodiment the subchannels have no more a periodicity and a phase that mark them in the multiframe, since the new nature of the regulation mechanism does not generate

a limitation of time nature accesses, but rather in the space of signature sequences.

The introduction of this other embodiment is less effective than the calculation of expression (1) and (2) because it does not averagedly reduce the collision probabilities on the UpPTS channel. The other embodiment actually reduces the quantity of signatures SYNC1 at disposal of the Mobile units during a single access, fact that in itself would increase the collision probabilities on a channel, but at the same time increases the access channels, decreasing at the same rate the number of signatures necessary for each single access. This means that in general the collision probabilities with, or without, the first other embodiment should in general remain unchanged. However, an advantage could be found in the short period and in presence of heavy traffic situations in particular mobile radio environments, urban microcells for instance. In this case a cautious selection of the signature sub-sets could avoid troublesome slackenings in service due to excessive handover requests. It is the Applicant's opinion that the first one of the other embodiments, in addition to the advantages immediately deriving, teaches an alternative method for the formation of subchannels, and as such it has right to a patent protection. The usefulness of the other embodiment, with no need to wait for future developments, can just from now be discovered in connection with the phases that immediately follow the transmission of a SYNC1, and namely in the phases of handshake with the network before the assignment of a dedicated channel. We have already seen before that the handshake is accelerated whenever links of the following type are created:

$$\text{SYNC1} \rightarrow \text{P-FACH} \rightarrow \text{P-RACH} \rightarrow \text{P/S-CCPCH}$$

just starting from a distinction among the different available SYNC1. The fact to have already shared the SYNC1 can help the formation of these links, because when a Mobile unit selects a SYNC1 it selects also the channels associated to the same.

It is now described a second other embodiment of the invention of the procedure employing the expression (1) or (2) as first approach for the generation of subchannels, but on selection of the signature to transmit, the Mobile applies also the criteria of the first different embodiment. This implies the selection of the SYNC1 to transmit among those of a sub-set described by SYNC1-RIP corresponding to a subchannel indicated by an identifier $\text{UpPTS}_{\text{SUBCH}}$ N° equal to the subchannel indicated by the parameters P1 and P2, in particular

by P2. In equivalent terms, it means that the access typology associated to the subchannel is the same in the two cases and can therefore prove to be synergy between the two criteria of subchannel determination. In the case of the second embodiment, the information corresponding to the above mentioned access parameters will include the parameters P1 and P2, and the information elements SYNC1-RIP and $UpPTS_{SUBCH}$ N°; it shall be transferred through the same channels and employing the same messages already described making reference to the preferred embodiment of the invention.

Figures 21 and 22 are two equivalent figures summarizing from the functional point of view the determination criteria of shared access subchannels scope of the preferred embodiment of the present invention, and of the two other embodiments .

Making reference to **fig. 21** and starting from left to right, the criteria succeed in decreasing general order. The first block announces the recourse to some access parameters to obtain subchannels tied to the access typology. The second block is preliminary to the two other embodiments, where it needs a sharing of the SYNC1, which must be introduced as limited to an assignment group. The third blocks are those in which the different options, opt1, opt.2, and opt.3 available to determine the subchannels are announced. The subsequent circular blocks indicate an alternative that shows to the Mobile only after having determined a subchannel, and in particular the method according to which it shall transmit the SYNC1 on the subchannel determined before, that is: in R = Random mode, or C = on Command previously received from the network. One of the other ways will lead to a result equivalent to a final option. Of course not all the options indicated in terminal blocks can be accepted, since there is repetition and inconsistency possibility. For instance the option indicated as OPTION 2-2 is inconsistent since it appears not to be logic that the network directs first a sharing of the signatures and then gives a new command of which specific signature has to be transmitted, of course it would be more reasonable to directly order the signature to transmit. The option denoted OPTION 3-2 is on the contrary a repetition of the option denoted OPTION 1-2. Inconsistency and repetition, once highlighted, shall be easily avoided in the phase of access parameter assignment for the determination of subchannels.

Making reference to **fig.22**, it can be noticed that the selection circular block of the transmission methods of signatures SYNC1, that is Random or on

Command of the network, precedes the blocks showing the different options for the determination of subchannels. This enables to eliminate just from the origin the inconsistency and repetition causes.

APPENDIX APP1

LEGEND (fig. 6)

PHL	PHysical Layer
MAC	Medium Access Control
LAPD	Link Access Protocol on the D channel
LAPDm	Link Access Protocol on the D channel modified
MTP	Message Transfer Part
RRM	Radio Resource Management
SCCP	Signalling Connection Control Part
MM	Mobility Management
CM	Connection Management
DTAP	Direct Transfer Application Part
BSS_MAP	Base Station System_Mobile Application Part.

TABLE A (LEVEL 2) (GSM – 3G)

INTERFACE				DESCRIPTION
	Um (Uu)	A-bis (A-bis similar)	A	
Trans-port functions	LAPDm (GSM 04.06)	LAPD		Both the protocols enable to transfer information relative to application levels, in the correct sequence. The two protocols are similar; the main difference lays in the fact that in the LAPD the signalling connections relevant to different users can be multiplexed on a same physical support, while in the LAPDm connections of different users result differentiated also at physical level.
			MTP	Enables to transfer on connections employing the shared channel signalling CCITT SS7 the information relevant to application levels, correctly and in sequence. It also enables to manage failure conditions with restoration of the signalling circuits.

TABLE B (LEVEL 3) (GSM – 3G)

INTERFACE				DESCRIPTION
	Um (Uu)	A-bis (A-bis similar)	A	
Transport functions			SCCP	Supplies additional services compared to MTP enabling, for instance, to establish a signalling connection that transfers information relevant to a Mobile between a BSS and an MSC.
Network functions	CM		CM	DTAP(CM) controls messages between MS and MSC that are transparent to BSS; it can be divided into three sublevels: • CC (CALL CONTROL): performs typical call control functions. • SS (SUPPLEMENTARY SERVICES): performs specific functions for access to Supplementary Services. • SMS (SHORT MESSAGE SERVICES): it is a teleservice that enables a Mobile to exchange information with a Service Centre acting as "store and forward".
	MM		MM	DTAP(MM) Manages messages between MS and MSC that are transparent for BSS. Defines the functions for the mobility management of Mobiles (affiliation, authentication).
			BSS-MAP	Controls the BSS performing typical functions of mobile networks.
Management of radio resources	RRM	RRM		Manages the Power Control, Frequency Hopping, Configuration functions of channels on the radio Frame, Ciphering, Handover. It includes: • A part enabling the dialogue between MS and BTS. • A part enabling the dialogue between MS and BSC. • A part enabling the dialogue between BSC and BTS.

APPENDIX APP2

TABLE 1: Number of symbols per Data field in the main burst (fig.12f)

Spreading Factor SF (Q_k)	N° of symbols per Data field in the main Burst
1	352
2	176
4	88
8	44
16	22

TABLE 2: Approximate data transmission speed at the different RU

Spreading factor (SF) (Q)	RU Name	Number of symbols (N) per data field in Burst	Approximate Data Rate (Bit/s) of the physical channel
1	RU_{SF1}	352	281.600
2	RU_{SF2}	176	140.800
4	RU_{SF4}	88	70.00
8	RU_{SF8}	44	35.200
16	RU_{SF16}, Basic RU	22	17.600

TABLE 3: Main modulation parameters

Chip rate	1.28 Mcps
Carrier spacing	1.6 MHz
Data modulation	QPSK
Chip modulation	Root-raised cosine Roll_off $\alpha = 0.22$
Spreading characteristics	Orthogonal (Q_k * chips) / symbol, where $Q_k = 2^p$, $0 \le p \le 4$

TABLE 4: LEVEL 1 FIELDS IN MAIN BURST

Parameters	Length in bits	Symbols in bursts
Synchronisation shift (SS)	2*16/SF	16/SF symbols after the midamble
Power Control (PC)	2*16/SF	16/SF symbols after SS symbols
Stealing Flag (SFL)	2*16/SF	16/SF symbols before the midamble

TABLE 5: Mapping of bits for Power Control PC

Bit Values	Corresponding actions
00	Increase Tx power of P_{step} dB
01	No action
10	No action
11	Decrease TX power of P_{step} dB

TABLE 6: Mapping of bits for Synchronisation shift SS

Bit Values	Corresponding actions
00	Increase the timing advance T_a by 1/k Tc
01	No action
10	No action
11	Decrease the timing advance T_a by 1/k T_c

TABLE 7: MAP OF LOGIC CHANNELS WITHIN PHYSICAL CHANNELS

PHYSICAL CHANNEL		LOGIC CHANNELS
DPCH	Dedicated Physical Channel	TCH, SACCH, FACCH
P-CCPCH	Primary-Common Control Physical Channel	COCH (BCCH, PCH, AGCH, optCH)
S-CCPCH	Secondary-Common Control Physical Channel	COCH (BCCH, PCH, AGCH, optCH)
P-RACH	Physical Random Access Channel	RACH
P-FACH	Physical Forward Access Channel	FACH (1 burst)
DwPTS	Downlink Pilot Timeslot	Performs SCH and FCCH tasks except carrying the FN Frame Number
UpPTS	Uplink Pilot Timeslot	SYNC1
PDPCH	Packet Data Physical Channel	PDTCH, PACCH

TABLE 8: Multiplexing of grouping of SYNC1 sequences among the time slots transporting P-FACH channels

No of time slot of P-FACH channel	SYNC1 are the 1st time slot	SYNC1 are the 2nd time slot	SYNC1 are the 3rd time slot	SYNC1 are the 4th time slot	SYNC1 are the 5th time slot	SYNC1 are the 6th time slot
1	1-8					
2	1-4	5-8				
3	1-3	4-6	7-8			
4	1-2	3-4	5-6	7-8		
5	1-2	3-4	5-6	7	8	
6	1-2	3-4	5	6	7	8

TABLE 9: Multiplexing of Common Control Channels in physical channels P-CCPCH

Transport channel	Interleaving Block and spacing
BCCH	1 (4 frames)
BCCH/PCH	2 (4 frames)
PCH	3 (4 frames)
PCH	4 (4 frames)
PCH	5 (4 frames)
PCH or other	6 (4 frames)
PCH or other	7 (4 frames)
PCH or other	8 (4 frames)
PCH or other	9 (4 frames)
PCH or other	10 (4 frames)
PCH or other	11 (4 frames)
PCH or other	12 (4 frames)

APPENDIX APP3

TABLE 1

Type of access procedure		Mobile Controlled (m.o.c.)	Network Controlled (m.t.c.)
Call Originated by Mobile	First part of Random Access (RA#1)	X	
	Second part of Random Access (RA#2)		X
Call ended towards Mobile (reply to paging)	First part of Random Access (RA#1)		X
	Second part of Random Access (RA#2)		X
Asynchronous Handover			X

TABLE 2

FN	P1	P2	Event
0	4	0	HO
1	4	1	RA#1
2	4	2	HO
3	4	3	RA#2
4	4	0	HO
5	4	1	RA#1
6	4	2	HO
7	4	3	RA#2
....	....	....	....

TABLE 3

FN	P1	P2	Event
0	4	0	RA#1
1	4	1	RA#2
2	4	2	RA#2
3	4	3	HO
4	4	0	RA#1
5	4	1	RA#2
6	4	2	RA#2
7	4	3	HO
....	....	....	....

TABLE 4

FN	P1	P2	Event
0	8	0	HO
1	8	1	RA#1 (m.o.c.)
2	8	2	HO
3	8	3	RA#2
4	8	4	HO
5	8	5	RA#1 (m.t.c.)
6	8	6	HO
7	8	7	RA#2
8	8	0	HO
9	8	1	RA#1 (m.o.c.)
10	8	2	HO
11	8	3	RA#2
12	8	4	HO
13	8	5	RA#1 (m.t.c.)
14	8	6	HO
15	8	7	RA#2
....	....	....	....

TABLE 5

ACCESS TYPOLOGY	Quantity of SYNC1	SHARING of SYNC1 SYNC1-RIP	$UpPTS_{SUBCH}$ N°
HO	4	$SYNC1_1$, ..., $SYNC1_4$	0/2/4/6
RA#1 (m.o.c.)	1	$SYNC1_5$	1
RA#1 (m.t.c.)	1	$SYNC1_6$	5
RA#2 (m.o.c. + m.t.c.)	2	$SYNC1_7$, $SYNC1_8$	3/7

CLAIMS

1. Access channel scheduling in a radio communication system including a plurality of Mobile units and in which the radio channel for the access to the network is shared by the Mobile units, subject to collisions and controlled by a base transceiver station (BTSC) of cellular telecommunication (3G) in communication with the Mobile units (UE) through at least one reception-transmission carrier conveying transmitted and received signals, generating bit sequences in base band, called bursts, included in adjacent time slots belonging to a serial frame, indefinitely repeated in a hierarchical multiframe (iperframe), each bit sequence having associated codes for the code division multiplexing on the common carrier; said transmitted and received signals including at least a pilot signal (DwPTS) transmitted by the base station towards the Mobile units within the frame to synchronise the reception of the Mobile units and indicate the position in the hierarchical multiframe of a service channel (BCCH) containing the broadcast diffused system information by the base station towards the Mobile units; said transmitted and received signals including identification sequences (SYNC1) transmitted by the Mobile units to said base station on said shared access channel (UpPTS), **characterized in that** it includes the following operational steps:

a) reading made by the Mobile units of appropriate access parameters (P1, P2, P3) inserted by the network in the system information carried by the above-mentioned service channel (BCCH) or in messages transmitted by the network at starting of procedures for the assignment of dedicated channels (TCH, SACCH, FACCH) to the Mobile units requesting at least an access of the Mobile units to the network;

b) generating by the Mobile units of the shared access subchannels ($UpPTS_{SUBCH}$) of said shared access channel (UpPTS), associating each subchannel to an access typology, through the use of said access parameters (P1, P2, P3);

c) transmission of one said identification sequence (SYNC1), or signature sequence, on one said shared access subchannel ($UpPTS_{SUBCH}$).

2. Access channel scheduling according to claim 1, characterized in that said signature sequences (SYNC1) belong to a group of signature sequences (GRUOP UpPTS N°) that the network associates to said reception-transmission carrier, signalling to the Mobile units the association methods through insertion of

an identification of the group in an initial message broadcast diffused by said service channel (BCCH).

3. Access channel scheduling according to claim 2, characterized in that a Mobile in said step c) transmits a signature sequence random selecting it among the available ones.

4. Access channel scheduling according to claim 2, characterized in that a Mobile unit in said phase c) transmits a signature sequence whose identification corresponds to one said access parameter (P3) read in said step a).

5. Access channel scheduling according to claim 3 or 4, characterized in that the Mobile units in said step b) use at least two first access parameters (P1, P2) for the calculation of a mathematical expression that gives a sequence of marked frames within the multiframe with repetition period and marking phase controlled by the values of said first parameters (P1, P2) to obtain said access subchannels ($UpPTS_{SUBCH}$), being said one subchannel made of the group of equal period and phase marked frames.

6. Access channel scheduling according to claim 5, characterized in that at least two first access parameters are two parameters P1 and P2 that the Mobile units introduce in the following formal expression:

SFN module [P1] = P2

to mark the frames numbered with the system frame number SFN as belonging to one said subchannel ($UpPTS_{SUBCH}$).

7. Access channel scheduling according to claim 5, characterized in that said at least two first access parameters are two parameters P1 and P2 that the Mobile units introduce in the following formal expression:

SFN module [P1] ≠ P2

to mark the frames numbered with the system frame number SFN as belonging to one said subchannel ($UpPTS_{SUBCH}$).

8. Access channel scheduling according to claim 5, characterized in that said at least two first access parameters are two parameters P1 and P2 that the Mobile units introduce in the following formal expression:

SFN module [P1] = P2

SFN module [P1] ≠ P2

to mark the numbered frames by the system frame number SFN as belonging to one said subchannel ($UpPTS_{SUBCH}$); said access parameters including also an indication of which one of the two expressions must be used.

9. Access channel scheduling according to any claim 6 to 8, characterized in that the values of said first two access parameters (P1, P2) are such to identify a subchannel placed inside a second repetition period in the multiframe, higher than or equal to said repetition period (P1) characterizing the subchannels; said second repetition period, or interleaving period, corresponding to the length of consecutive blocks of frames assigned to said service channel carrying said system information, a starting frame of the second interleaving period being signalled with known techniques employing an information purposely impressed in the burst of said pilot signal (DwPTS) downlink transmitted by the base station, making thus possible the establishment of said shared access subchannels on the basis of the sole knowledge of a reduced frame number SFN' whose numbering starts coinciding with the starting of said second repetition period and repeats at the same intervals, and replaces said absolute frame number SFN in said mathematical expressions supplying said shared access subchannels.

10. Access channel scheduling according to claim 3, characterized in that a Mobile unit:

- in said step a) reads second access parameters (SYNC1-RIP, $UpPTS_{SUBCH}$ N°), and
- in said step b) employs the second access parameters to share said signature sequences (SYNC1) of said group assigned by the network (GROUP UpPTS N°), in a number (N°) of separate sub-sets of said signature sequences, possibly of one sole element, each sub-set ($UpPTS_{SUBCH}$ N°) being associated to said shared access subchannel ($UpPTS_{SUBCH}$).

11. Access channel scheduling according to any claims 5 to 10, when they depend on claim 3, characterized in that a Mobile unit in said step b):

- calculates said mathematical expression according to said first two access parameters (P1, P2) to mark the numbered frames forming a subchannel, and
- shares said signature sequences (SYNC1) as indicated by said second access parameters (SYNC1-RIP, $UpPTS_{SUBCH}$ N°) to obtain said sub-sets of signature sequences associated to subchannels ($UpPTS_{SUBCH}$ N°); said second (SYNC1-RIP, $UpPTS_{SUBCH}$ N°) access parameters determining a

shared access subchannel ($UpPTS_{SUBCH}$) associated to the same access typology as that determined using said first two access parameters (P1, P2).

12. Access channel scheduling according to any previous claim, characterized in that it also includes the following steps consecutive to said step c):

d) wait by the Mobile units for a reply message (PHYSICAL INFORMATION) coming from the network and including at least the following information elements: a correlative of the signature transmitted (SYNC1), said access parameters (P1, P2, P3, SYNC1-RIP, $UpPTS_{SUBCH}$ N°) and commands to synchronize the timing and the power level of a signal that shall be transmitted by the Mobile units in a step coming immediately after (CHANNEL REQUEST, HANDOVER ACCESS) included in the procedure in progress;

e) reiteration by the Mobile units of said step c) for the transmission of a signature sequence (SYNC1) and of said wait step d), until the reception of one said reply message (PHYSICAL INFORMATION) within a predetermined number of attempts before aborting the assignment procedure of one said dedicated channel (TCH, SACCH, FACCH).

13. Access channel scheduling according to claim 12, characterized in that before the assignment of one said dedicated channel (TCH, SACCH, FACCH) the Mobile units repeat said step c) for the transmission of a signature sequence (SYNC1) on said access subchannels ($UpPTS_{SUBCH}$) determined through said access parameters (P1, P2, SYNC1-RIP, $UpPTS_{SUBCH}$ N°) included in said reply message (PHYSICAL INFORMATION) received in said step e).

14. Access channel scheduling according to claim 13, characterized in that said access parameters (P1, P2, SYNC1-RIP, $UpPTS_{SUBCH}$ N°) generate different access subchannels ($UpPTS_{SUBCH}$) within a same assignment procedure of a dedicated channel (TCH, SACCH, FACCH).

15. Access channel scheduling according to any of the previous claims, characterized in that said shared access subchannels are released on completion of the assignment to the Mobile units of said dedicated channels (TCH, SACCH, FACCH).

16. Mobile system performing the access channel scheduling of claim 1, including:

– means placed in the base transceiver stations (BTSC) and in the Mobile units (UE) for the generation of bit sequences in base band corresponding to the

signals transmitted and received, occupying adjacent time slots of a serial frame indefinitely repeated within a hierarchical multiframe associated to a receipt-transmission radiofrequency carrier;

- a set of codes associated to said bit sequences for the code division multiplexing on the shared carrier;
- means placed in the base transceiver station (BTSC) for the generation of a pilot signal (DwPTS) broadcast transmitted within the frame to synchronise the reception of the Mobile units and indicate the position in the hierarchical multiframe (iperframe) of a service channel (BCCH) containing a system information diffused towards the Mobile units;
- means placed in the Mobile units (UE) to discriminate said pilot signal (DwPTS) and perform the operations indicated;
- means included both in the base station (BTSC) and in the Mobile units (UE), particularly suitable for the execution of protocols foreseen at the interface radio (Uu) for the exchange of messages having different information content;
- means placed in the Mobile units (UE) to generate identification sequences (SYNC1) to transmit to said base station (BTSC) on an access channel to he network (UpPTS) shared by the Mobile units and subject to collisions;

characterized in that it also includes:

- means placed in the Mobile units for the reading and storage of the information content of messages coming from said service channel (BCCH) or coming from messages transmitted by the network, at starting of procedures for the assignment of dedicated channels (TCH, SACCH, FACCH) to the Mobile units requiring at least an access of the Mobile units to the network; said information contents including appropriate access parameters (P1, P2, P3, SYNC1-RIP, $UpPTS_{SUBCH}$ N°);
- means placed in the Mobile units for the generation of shared access subchannels ($UpPTS_{SUBCH}$) of said shared access channel (UpPTS), said means associating each subchannel to an access typology;
- means placed in the Mobile units for the transmission of an identification sequence (SYNC1), called also signature sequence, on one said shared access subchannel ($UpPTS_{SUBCH}$).

17. Mobile system according to claim 16, characterized in that said signature sequences (SYNC1) belong to a group of signature sequences

(GRUPPO UpPTS N) that the network associates to said reception-transmission carrier, signalling to the Mobile units the association modes through the insertion of an identifier of the group in a start message broadcast diffused by said service channel (BCCH).

18. Mobile system according to claim 17, characterized in that the means placed in the Mobile units for the transmission of a signature sequence (SYNC1), randomly select the sequence among the available ones.

19. Mobile system according to claim 17, characterized in that the means placed in the Mobile units for the transmission of a signature sequence (SYNC1), transmit a signature sequence whose identification corresponds to one said access parameter (P3) stored by said means placed in the Mobile units for the reading and storage of the information contents of messages coming from the network.

20. Mobile system according to claim 18 or 19, characterized in that said means placed in the Mobile units for the generation of shared access subchannels ($UpPTS_{SUBCH}$) employ at least two first access parameters (P1, P2) in the calculation of a mathematical expression that gives a sequence of marked frames within the multiframe with repetition period and marking phase controlled by the values of said first parameters (P1, P2), to obtain said shared access subchannels ($UpPTS_{SUBCH}$), being one said subchannel made of the set of marked frames having equal period and phase.

21. Mobile system according to claim 20, characterized in that said means placed in the Mobile units for the generation of shared access subchannels introduce said first two parameters P1 and P2 in the following formal expression:

$$\text{SFN module}[P1] = P2$$

to mark the numbered frames by the system frame number SFN as belonging to one said subchannel ($UpPTS_{SUBCH}$).

22. Mobile system according to claim 20, characterized in that said means placed in the Mobile units for the generation of shared access subchannels introduce said first two parameters P1 and P2 in the following formal expression:

$$\text{SFN module}[P1] \neq P2$$

to mark the numbered frames by the system frame number SFN as belonging to one said subchannel ($UpPTS_{SUBCH}$).

23. Mobile system according to claim 20, characterized in that said means placed in the Mobile units for the generation of shared access subchannels introduce said first two parameters P1 and P2 in the following formal expressions:

$$SFN\ module[P1] = P2$$

$$SFN\ module[P1] \neq P2$$

to mark the numbered frames by the number of system frame SFN as belonging to one said subchannel ($UpPTS_{SUBCH}$); said first access parameters (P1, P2, SYNC1-RIP, $UpPTS_{SUBCH}$ N°) including also an indication of which one of the two expressions must be employed.

24. Mobile system according to any claim 21 to 23, characterized in that the values of said first two access parameters (P1, P2) are such to identify a subchannel placed inside a second repetition period in the multiframe, higher than or equal to said repetition period (P1) characterising the subchannels; said second repetition, or interleaving period, corresponding to the length of consecutive blocks of frames assigned to said service channel carrying said system information, a starting frame of the second interleaving period being signalled with known techniques that employ an information purposely impressed within the burst of said pilot signal (DwPTS) downlink transmitted by the base station, making thus possible the formation of said shared access subchannels on the basis of the sole knowledge of a reduced frame number SFN' whose numbering starts coinciding with the starting of one said second repetition period and repeats at the same regular intervals, and replaces said absolute frame number SFN in said mathematical expressions giving said shared access subchannels.

25. Mobile system according to claim 18, characterized in that the means placed in the Mobile units for the generation of shared access subchannels using second access parameters (P3, SYNC1-RIP, $UpPTS_{SUBCH}$ N°) to share said signature sequences (SYNC1) of said group (GRUPPO UpPTS N°), in a number (N°) of separate sub-sets of said signature sequences, possibly of a single element, associated to said subchannels ($UpPTS_{SUBCH}$).

26. Mobile system according to any claim 20 through 25, when depend on the 18, characterized in that the means placed in the Mobile units for the generation of subchannels to shared access employ:

- said two first access parameters (P1, P2) to calculate said mathematical expression to identify the numbered frames forming a subchannel, and
- said second access parameters (SYNC1-RIP, $UpPTS_{SUBCH}$ N°) to share the signature sequences (SYNC1) in a number (N°) of disjoined sub-sets of said signature sequences; said second (SYNC1-RIP, $UpPTS_{SUBCH}$ N°) access parameters determining a shared access subchannel ($UpPTS_{SUBCH}$) associated to the same access typology of the one determined using said two first access parameters (P1, P2).

27. *Mobile system according to any claim 16 through 26, characterized in that* said shared access subchannels are released on completion of the assignment to the Mobile units of said dedicated channels (TCH, SACCH, FACCH).

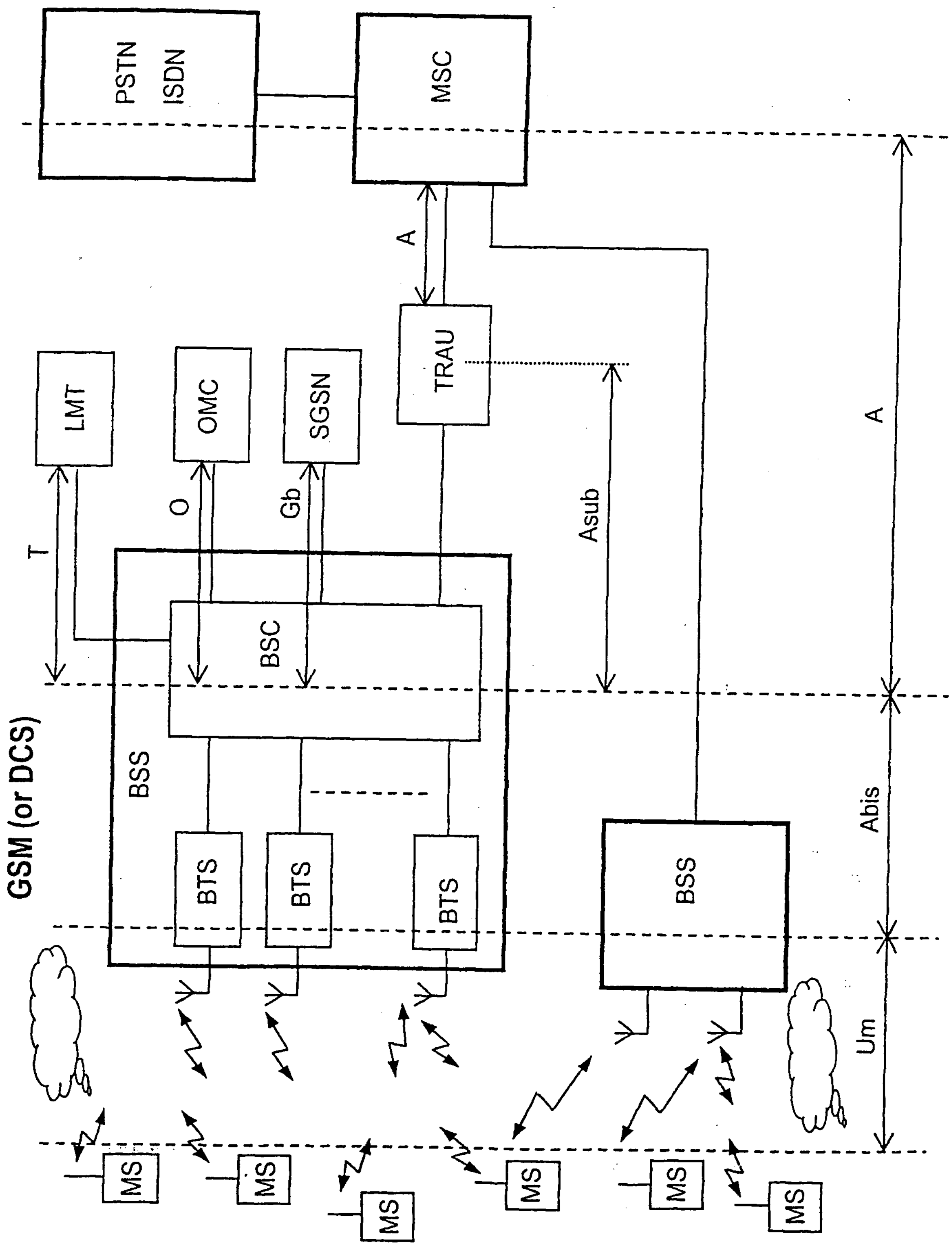
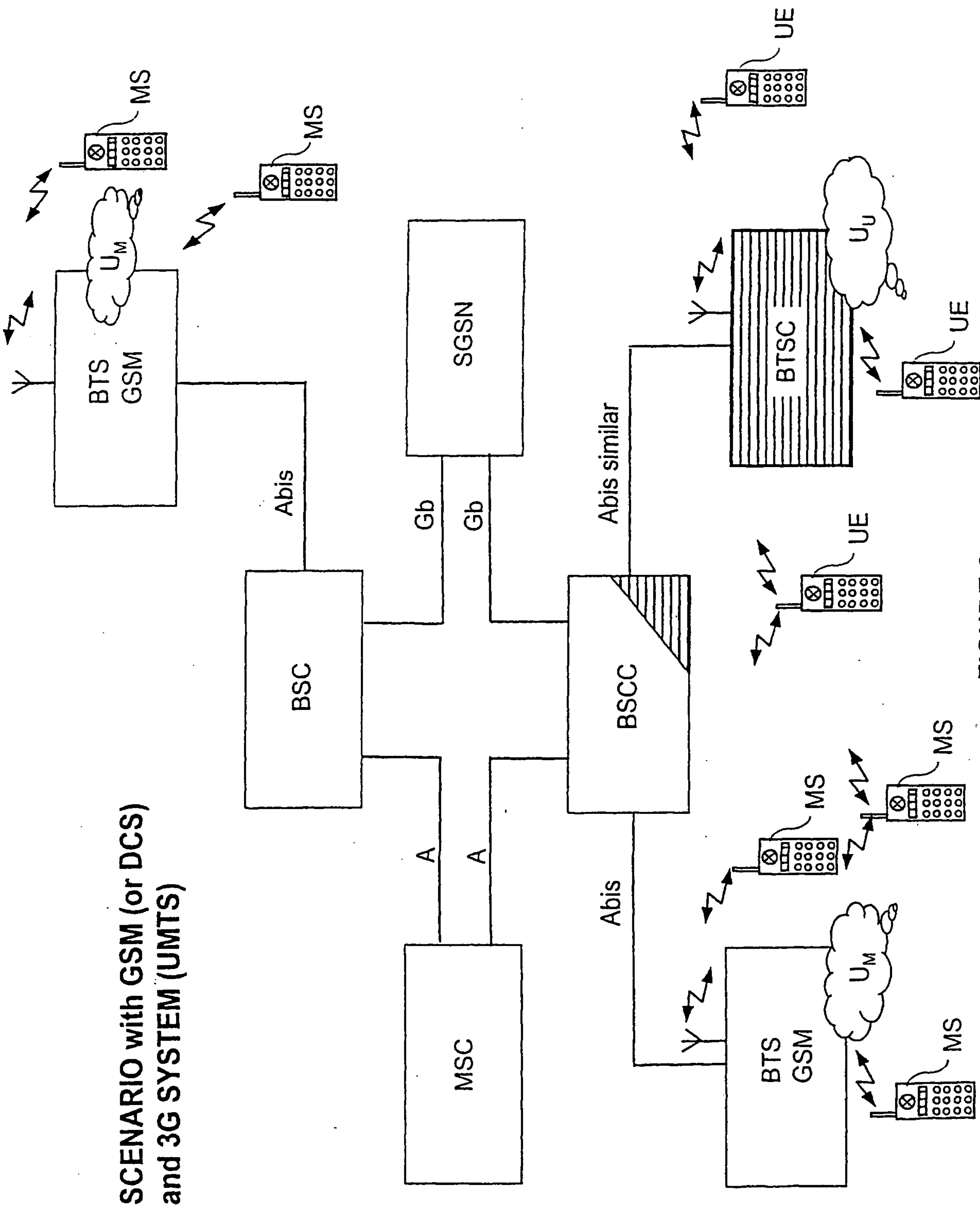

GSM (or DCS)
PSTN
ISDN
MSC
A
TRAU
LMT
OMC
SGSN
T
O
Gb
Asub
A
BSC
BSS
BTS
BTS
BTS
BSS
Abis
Um
MS
MS
MS
MS
MS
MS

FIGURE 1



SCENARIO with GSM (or DCS) and 3G SYSTEM (UMTS)

FIGURE 2

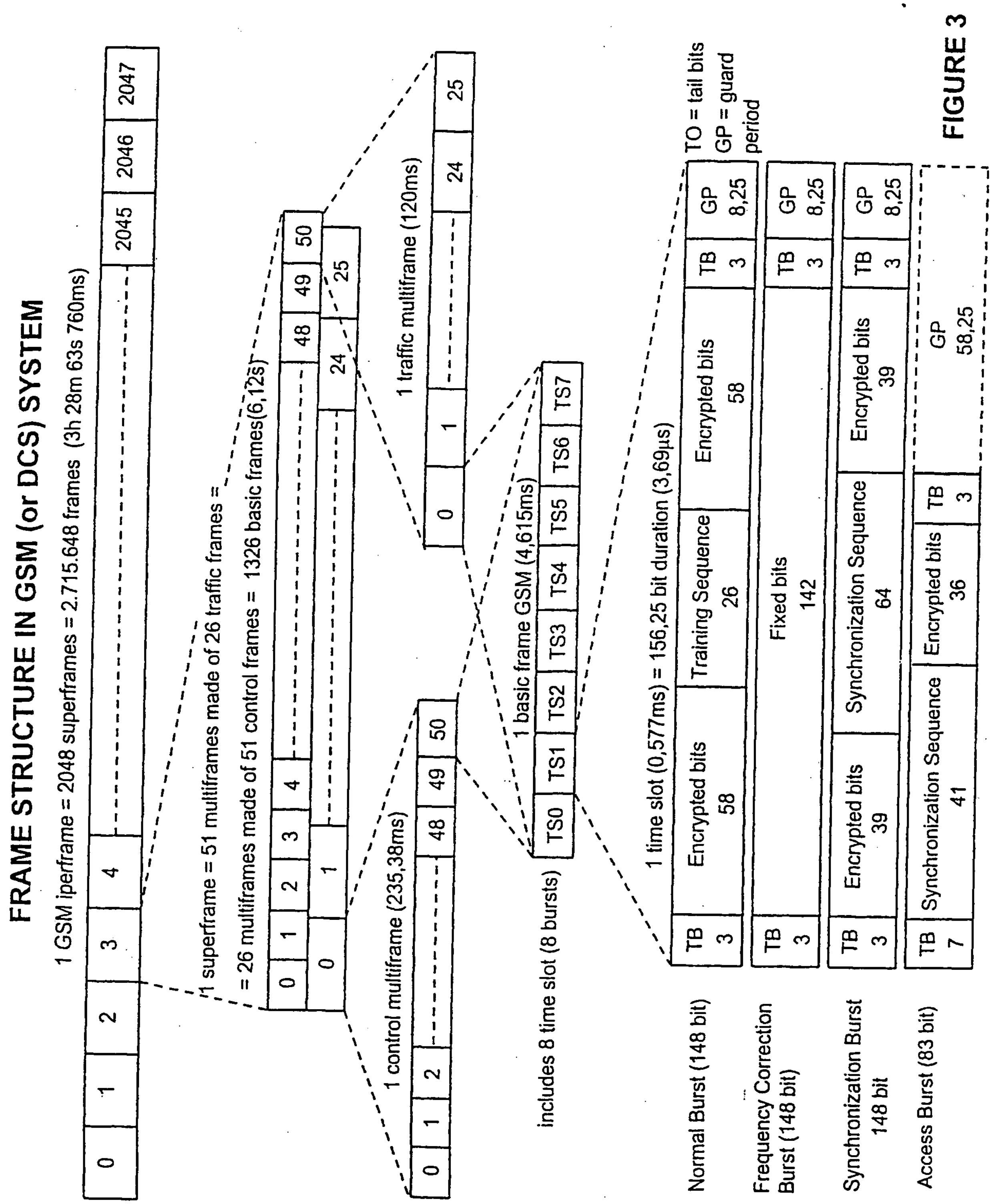

FRAME STRUCTURE IN GSM (or DCS) SYSTEM
1 GSM iperframe = 2048 superframes = 2.715.648 frames (3h 28m 63s 760ms)
0
1
2
3
4
2045
2046
2047
1 superframe = 51 multiframes made of 26 traffic frames =
= 26 multiframes made of 51 control frames = 1326 basic frames(6,12s)
0
1
2
3
4
48
49
50
0
1
24
25
1 control multiframe (235,38ms)
0
1
2
48
49
50
1 traffic multiframe (120ms)
0
1
24
25
1 basic frame GSM (4,615ms)
includes 8 time slot (8 bursts)
TS0
TS1
TS2
TS3
TS4
TS5
TS6
TS7
1 time slot (0,577ms) = 156,25 bit duration (3,69µs)
Normal Burst (148 bit)
TB 3
Encrypted bits 58
Training Sequence 26
Encrypted bits 58
TB 3
GP 8,25
Frequency Correction Burst (148 bit)
TB 3
Fixed bits 142
TB 3
GP 8,25
Synchronization Burst 148 bit
TB 3
Encrypted bits 39
Synchronization Sequence 64
Encrypted bits 39
TB 3
GP 8,25
Access Burst (83 bit)
TB 7
Synchronization Sequence 41
Encrypted bits 36
TB 3
GP 58,25
TO = tail bits
GP = guard period

FIGURE 3

LOGIC CHANNELS FORSEEN IN GSM 900 and DCS 1800 SYSTEMS

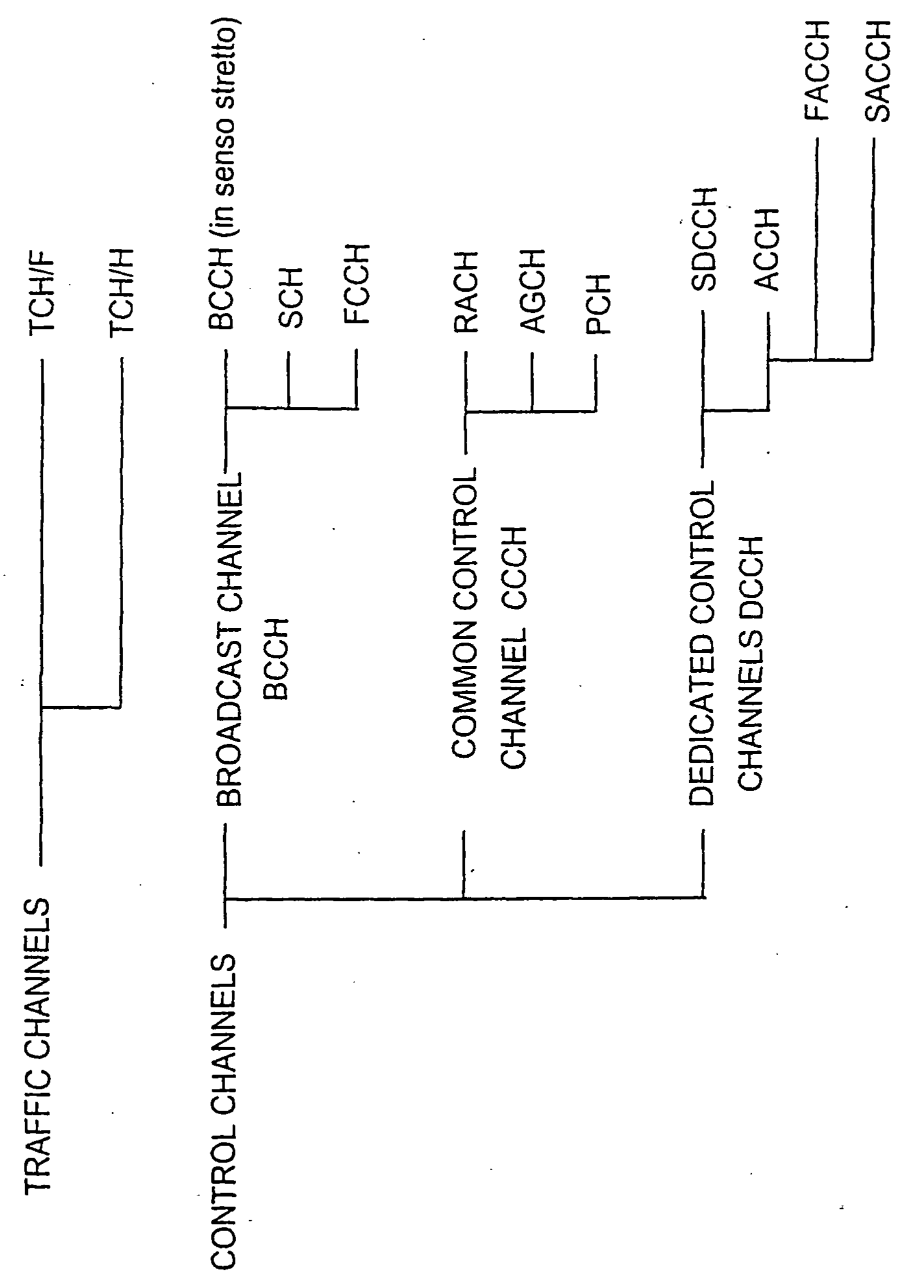


FIGURE 4

GSM (or DCS) ORGANIZATION OF LOGIC CHANNELS WITHIN THE MULTIFRAME

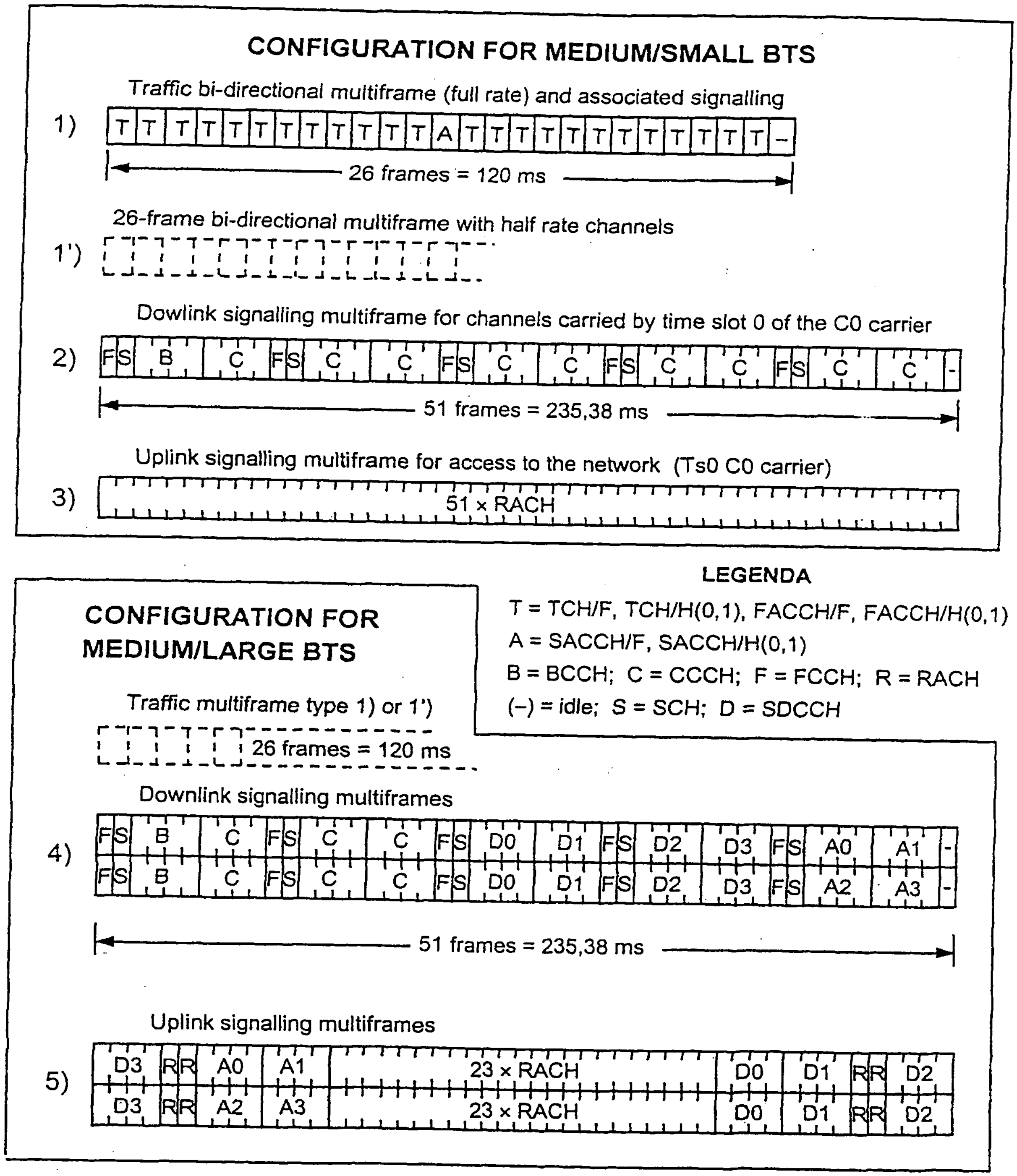


FIGURE 5

SUBSTITUTE SHEET (RULE 26)

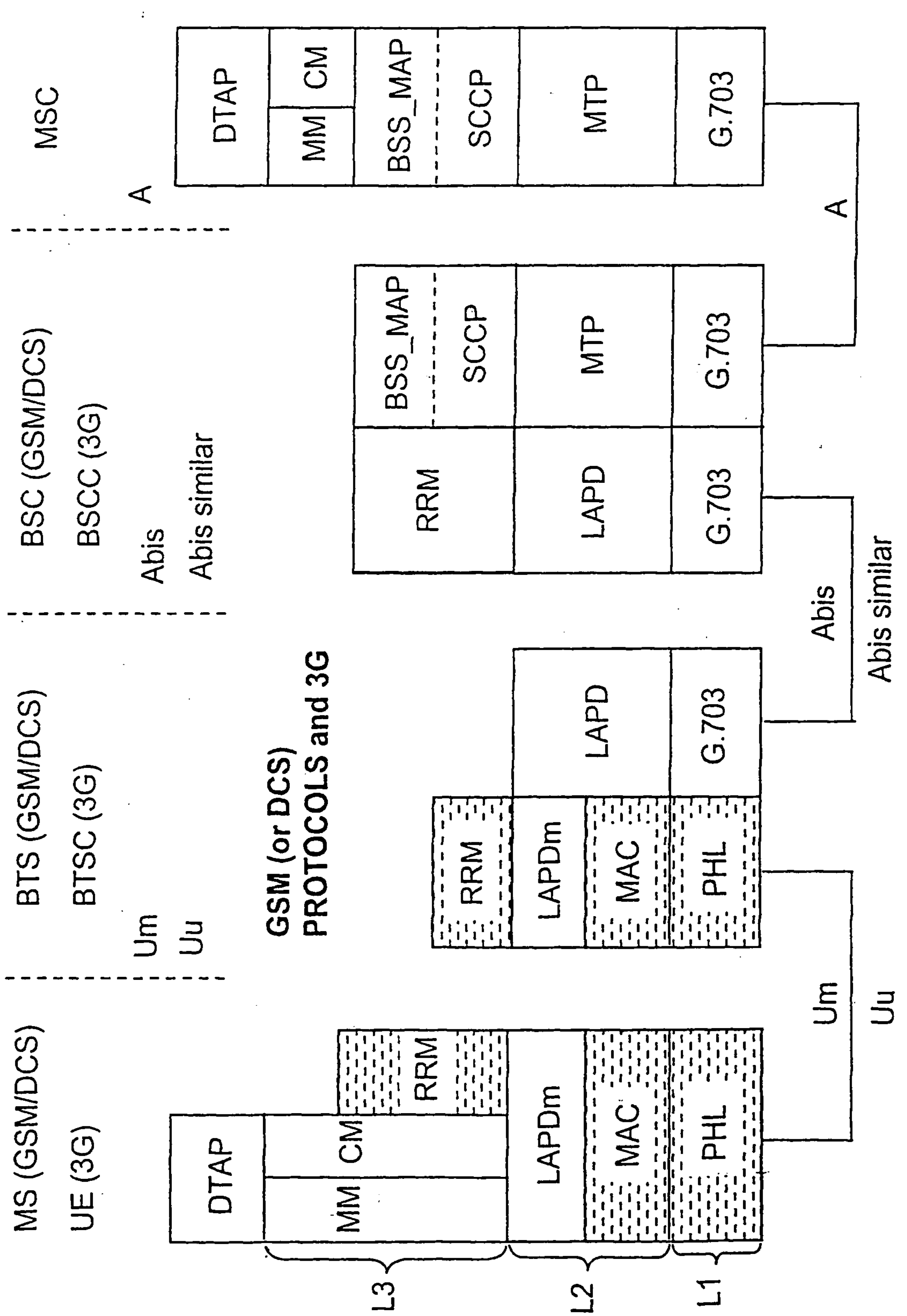

MS (GSM/DCS)
UE (3G)
BTS (GSM/DCS)
BTSC (3G)
Um
Uu
BSC (GSM/DCS)
BSCC (3G)
Abis
Abis similar
MSC
A
GSM (or DCS)
PROTOCOLS and 3G
DTAP
MM
CM
RRM
LAPDm
MAC
PHL
LAPD
G.703
BSS_MAP
SCCP
MTP
L3
L2
L1

FIGURE 6

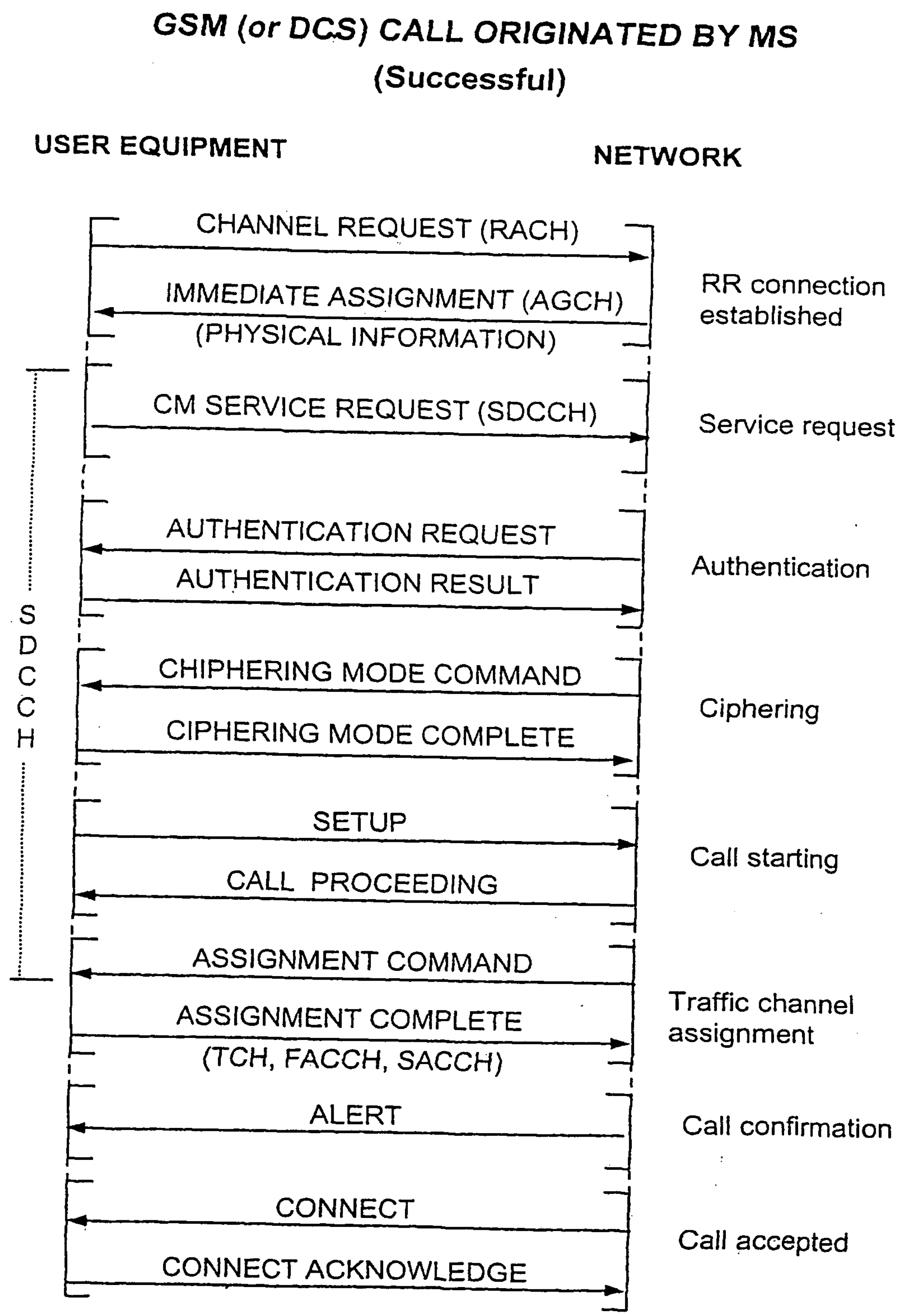

GSM (or DCS) CALL ORIGINATED BY MS
(Successful)
USER EQUIPMENT
NETWORK
CHANNEL REQUEST (RACH)
IMMEDIATE ASSIGNMENT (AGCH)
(PHYSICAL INFORMATION)
RR connection established
CM SERVICE REQUEST (SDCCH)
Service request
AUTHENTICATION REQUEST
AUTHENTICATION RESULT
Authentication
CHIPHERING MODE COMMAND
CIPHERING MODE COMPLETE
Ciphering
SETUP
CALL PROCEEDING
Call starting
ASSIGNMENT COMMAND
ASSIGNMENT COMPLETE
(TCH, FACCH, SACCH)
Traffic channel assignment
ALERT
Call confirmation
CONNECT
CONNECT ACKNOWLEDGE
Call accepted
SDCCH

FIGURE 7

GSM (or DCS) ENDED CALL (Successful)

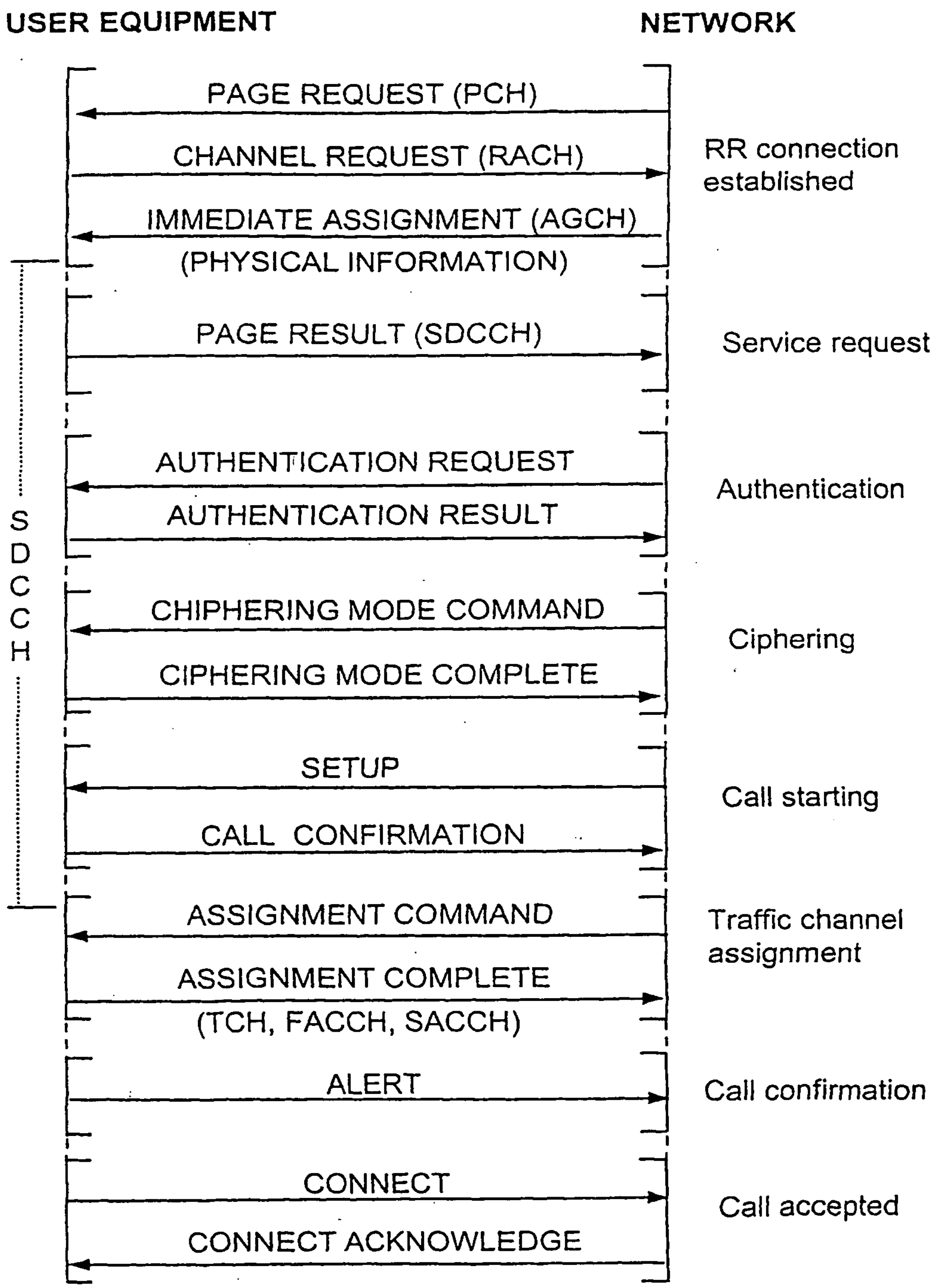


FIGURE 8

GSM (or DCS) INTERCELL HANDOVER (Successful)

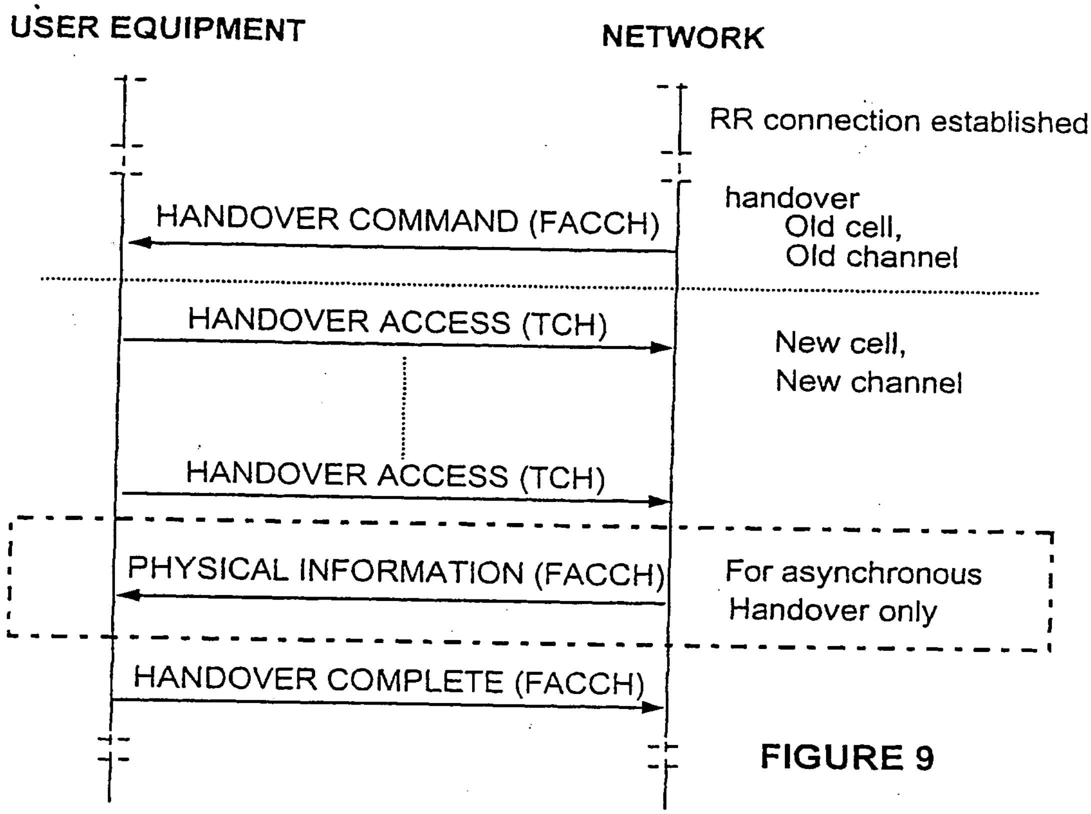


FIGURE 9

HANDOVER FAILED - re-connection to the old channel

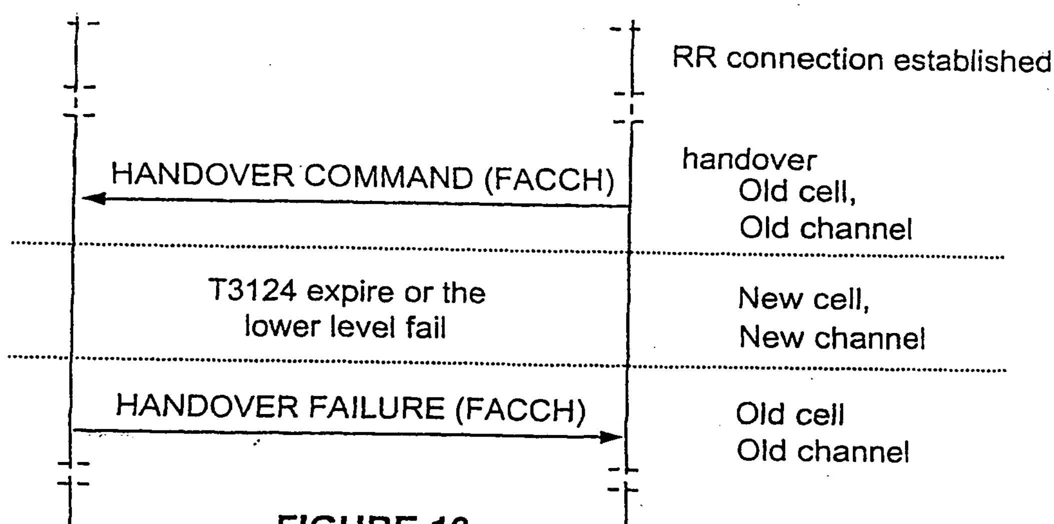


FIGURE 10

FRAME STRUCTURE IN 3G SYSTEM

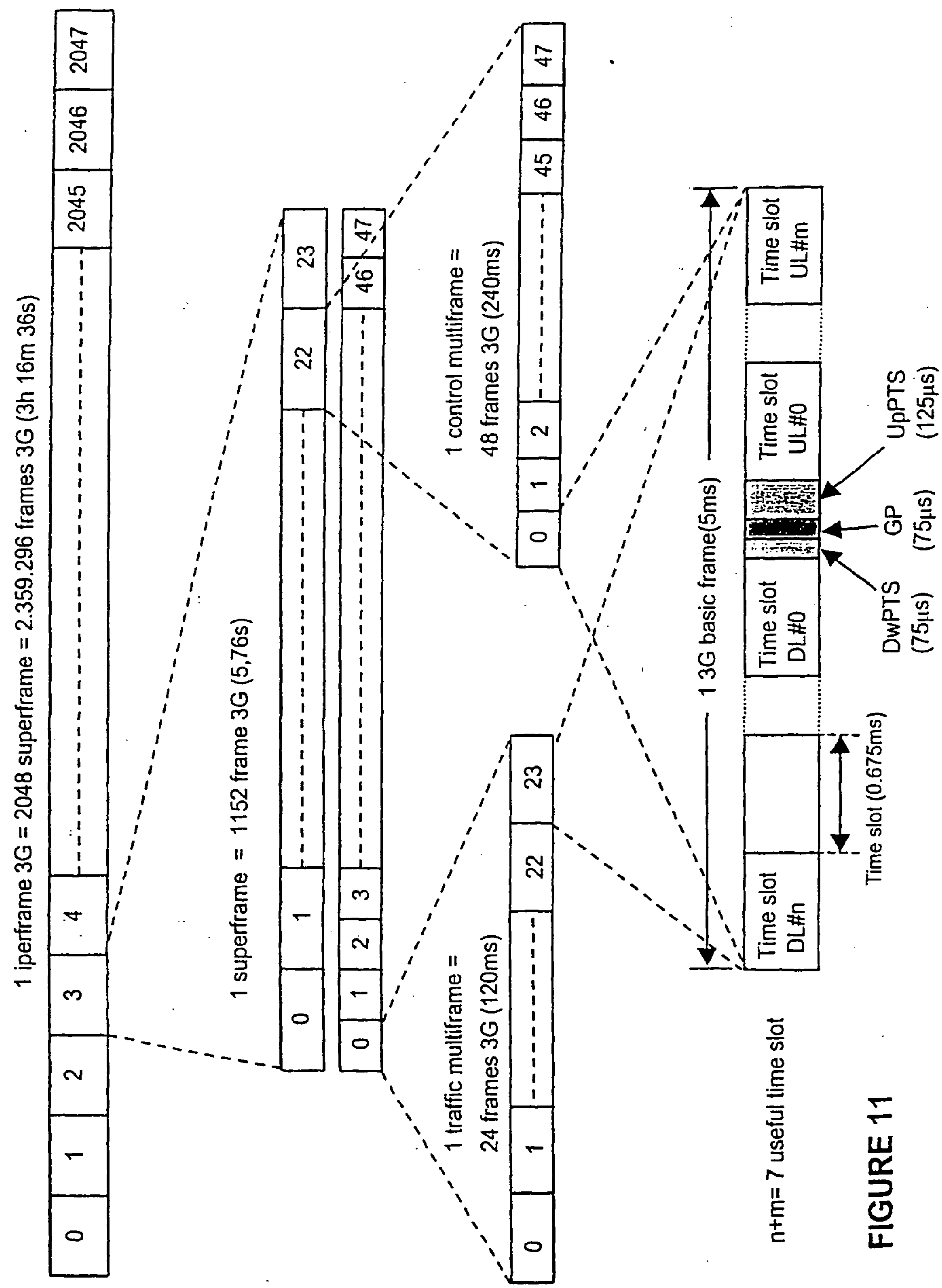


FIGURE 11

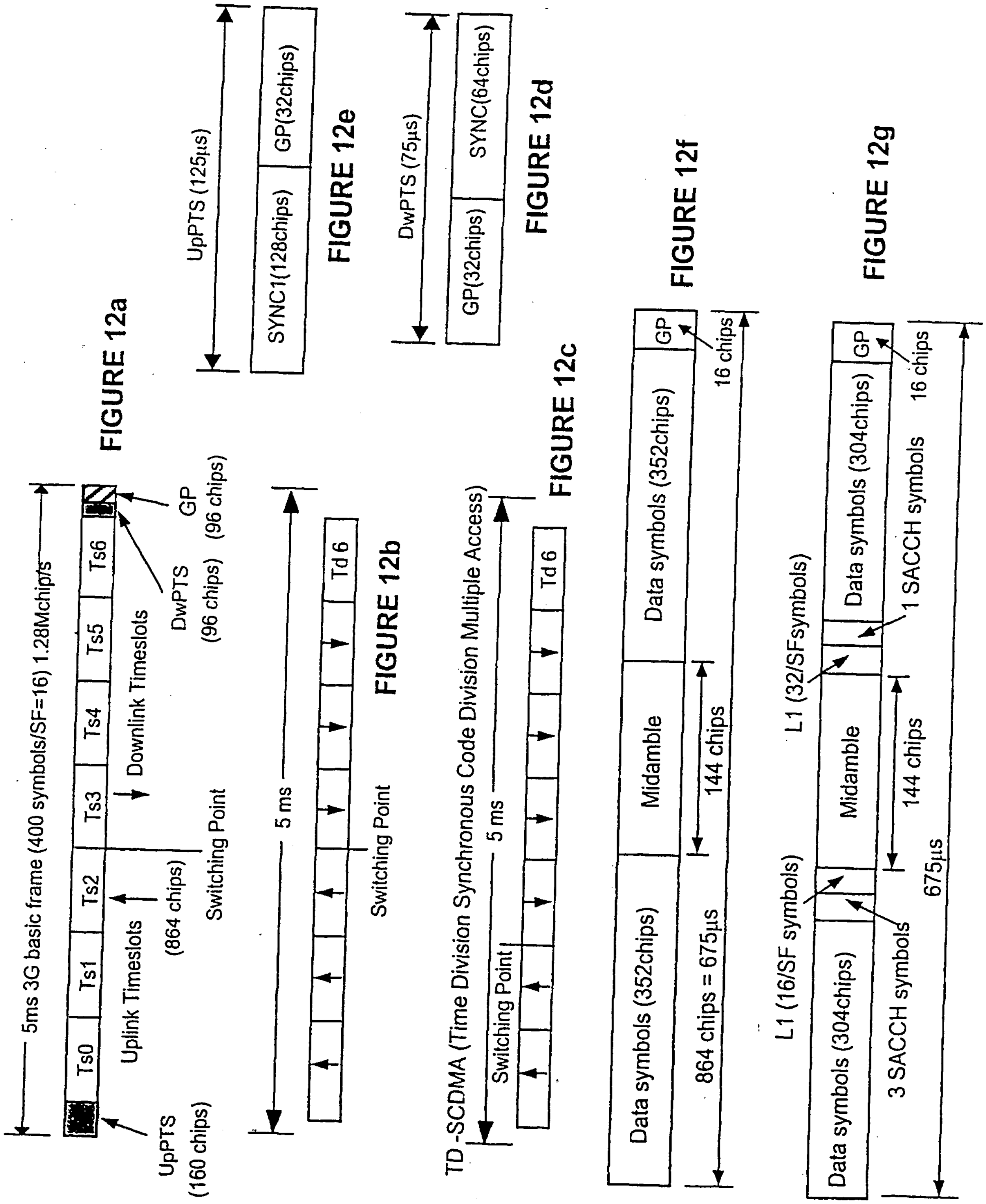


FIGURE 12a

FIGURE 12b

FIGURE 12c

FIGURE 12d

FIGURE 12e

FIGURE 12f

FIGURE 12g

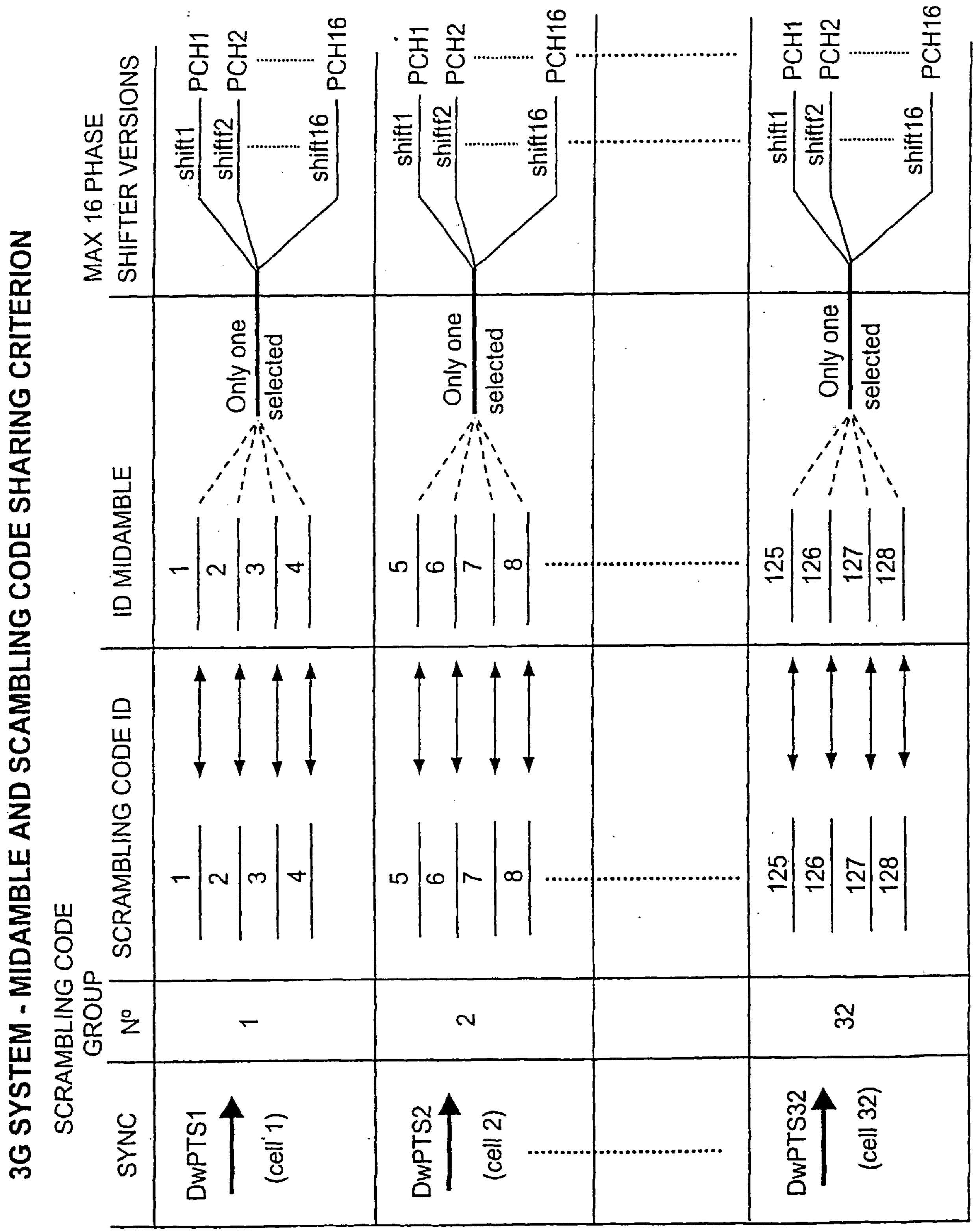

3G SYSTEM - MIDAMBLE AND SCAMBLING CODE SHARING CRITERION
SYNC
SCRAMBLING CODE GROUP
Nº
SCRAMBLING CODE ID
ID MIDAMBLE
MAX 16 PHASE SHIFTER VERSIONS
DwPTS1
(cell 1)
1
1 2 3 4
1 2 3 4
Only one selected
shift1 shift2 shift16
PCH1 PCH2 PCH16
DwPTS2
(cell 2)
2
5 6 7 8
5 6 7 8
Only one selected
shift1 shift2 shift16
PCH1 PCH2 PCH16
DwPTS32
(cell 32)
32
125 126 127 128
125 126 127 128
Only one selected
shift1 shift2 shift16
PCH1 PCH2 PCH16

FIGURE 13

3G SYSTEM - SYNCHRONIZATION SEQUENCES UpPTS (SYNC1) AVAILABLE TO USER EQUIPMENT

UpPTS GROUP N°	SYNC1 ID	
1 (cell 1) DwPTS1	1 2 3 4 5 6 7 8	1 of 8 SYNC1 random selected by mobile units of the cell in a corresponding uplink time slot
2 (cell 2) DwPTS2	9 10 11 12 13 14 15 16	1 of 8 SYNC1 random selected by mobile units of the cell in a corresponding uplink time slot
⋮	⋮	⋮
32 (cell 32) DwPTS32	248 249 250 252 253 254 255 256	1 od 8 SYNC1 random selected by mobile units of the cell in a corresponding uplink time slot

Code lengths

SYNC = 64 bit
SYNC1 = 128 bit
MIDAMBLE = 128 bit
SCRAMBLING CODE = 16 bit (±)

FIGURE 14

LOGIC CHANNELS FORESEEN IN THE 3G SYSTEM

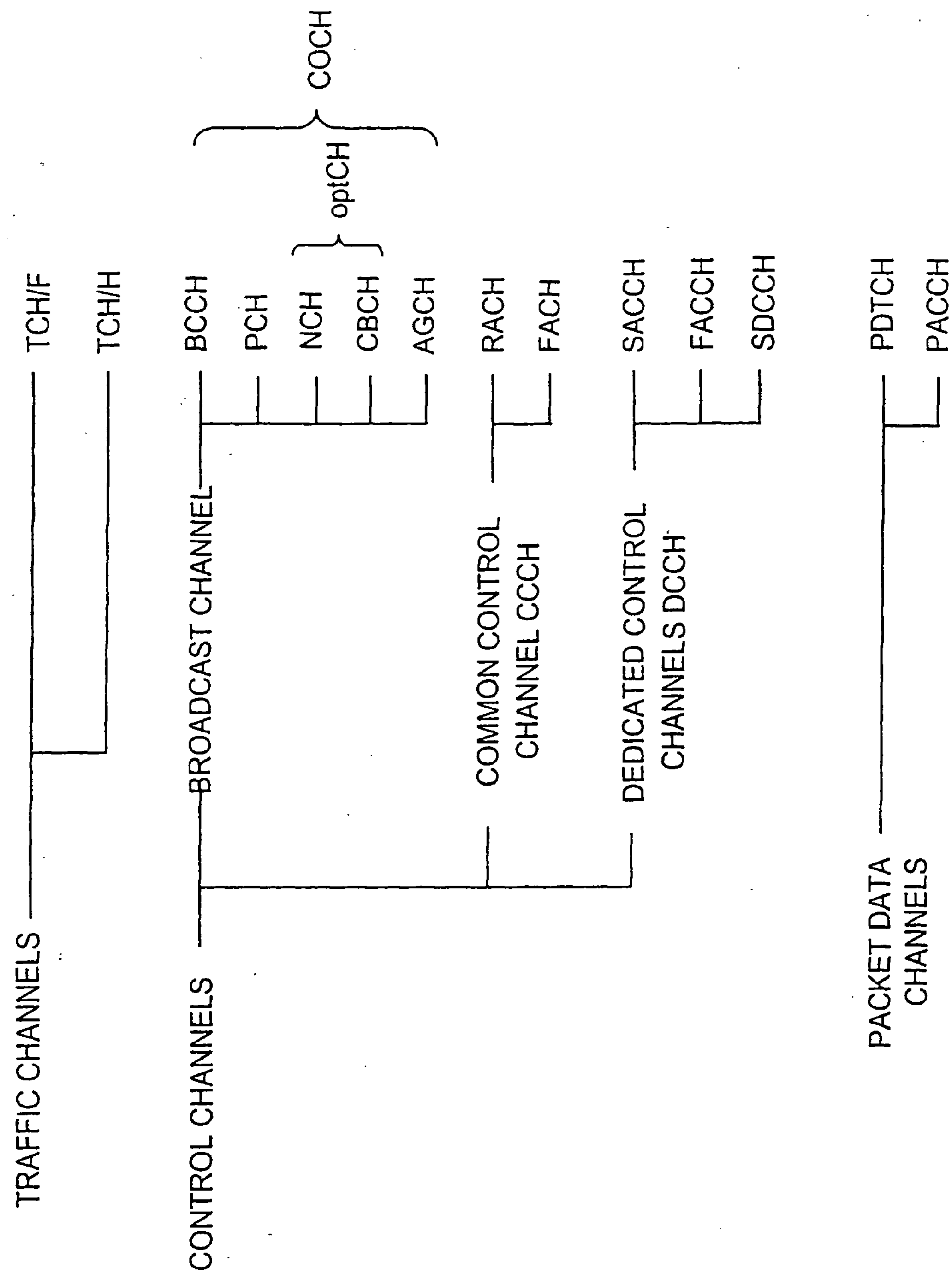


FIGURE 15

3G SYSTEM: PHYSIC AND LOGIC CHANNELS

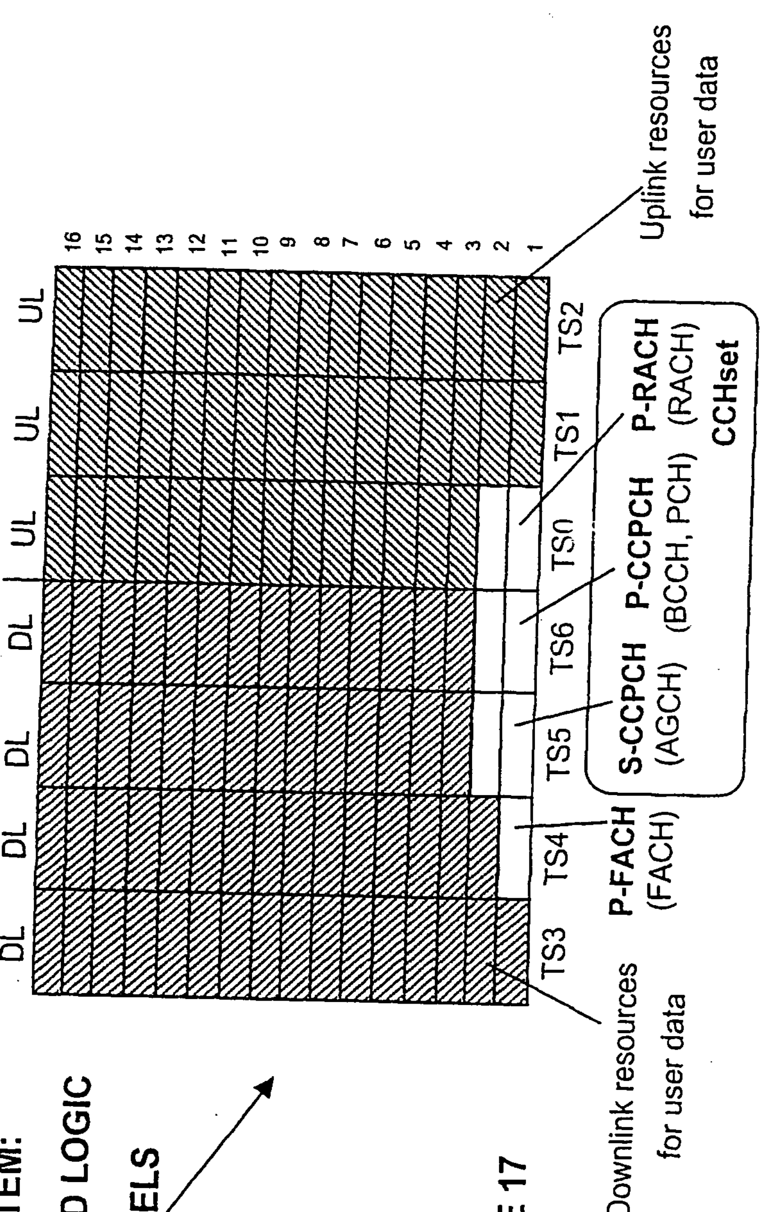


FIGURE 17

SACCH Channels in GSM e 3G multiframes

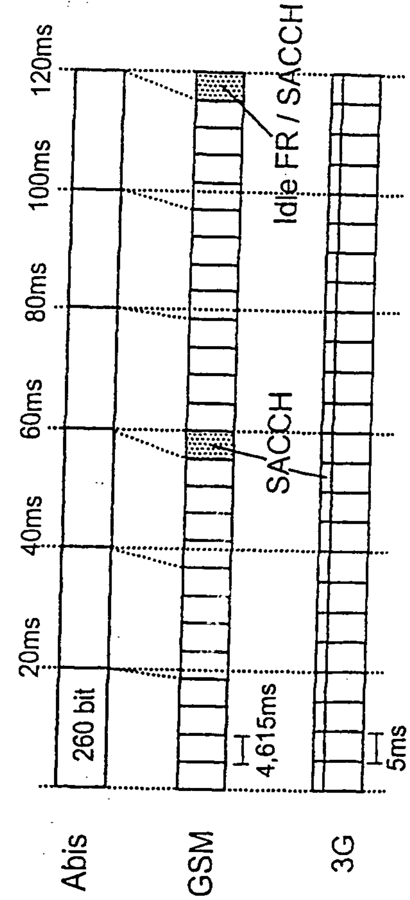


FIGURE16

3G SYSTEM: CALL ORIGINATED BY MS (Successful)

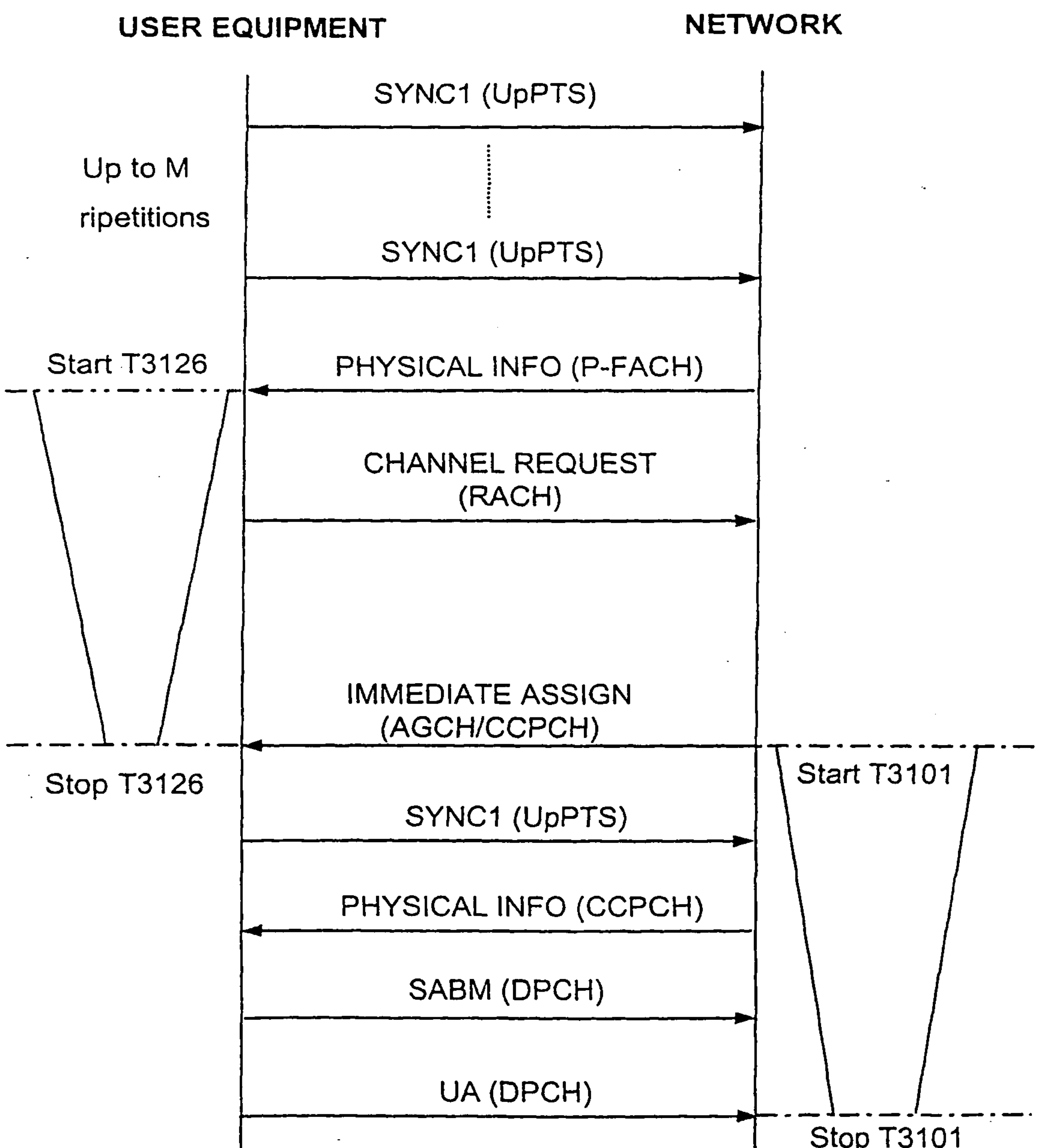


FIGURE 18

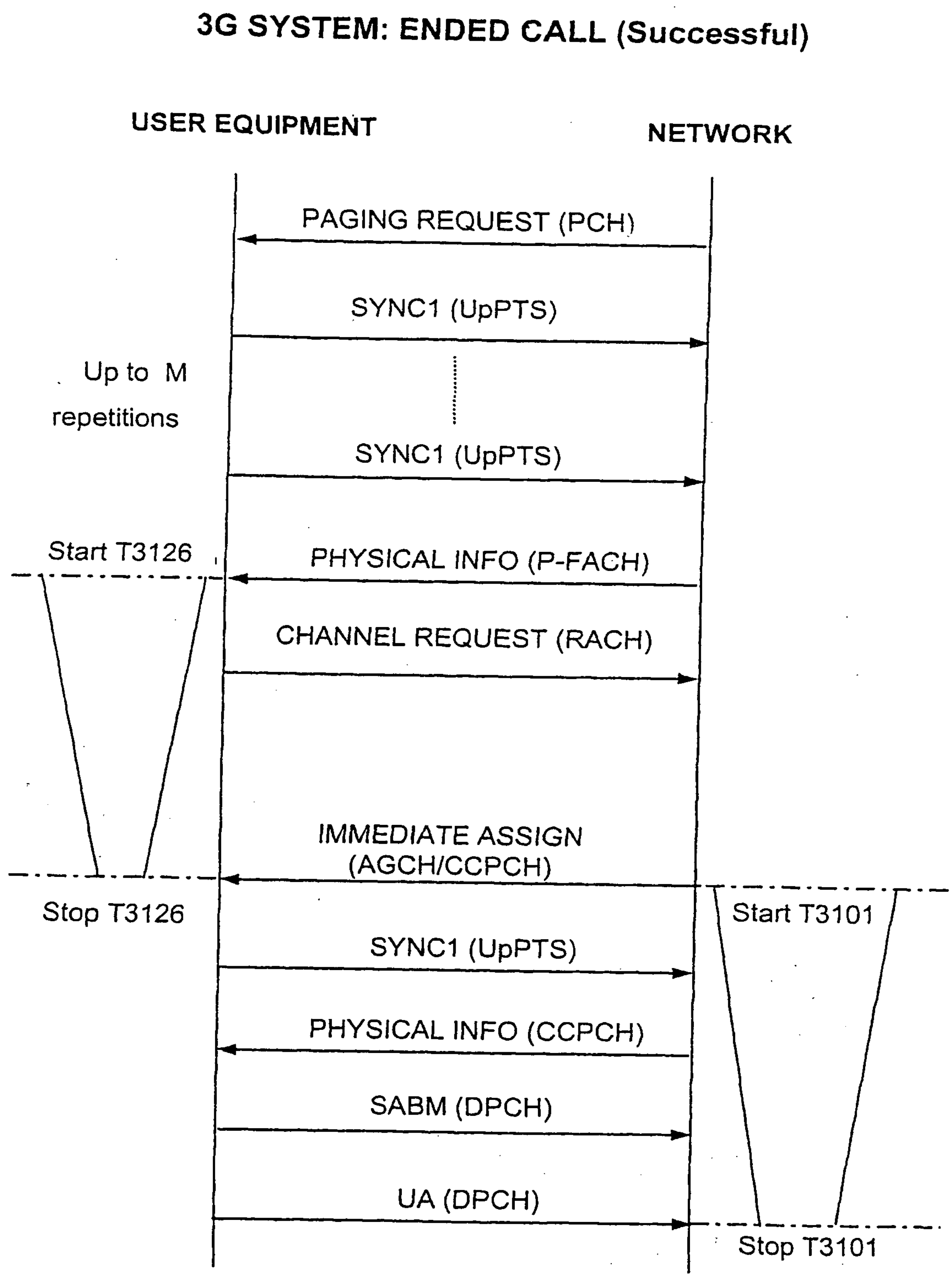

3G SYSTEM: ENDED CALL (Successful)
USER EQUIPMENT
NETWORK
PAGING REQUEST (PCH)
SYNC1 (UpPTS)
Up to M repetitions
SYNC1 (UpPTS)
Start T3126
PHYSICAL INFO (P-FACH)
CHANNEL REQUEST (RACH)
IMMEDIATE ASSIGN (AGCH/CCPCH)
Stop T3126
Start T3101
SYNC1 (UpPTS)
PHYSICAL INFO (CCPCH)
SABM (DPCH)
UA (DPCH)
Stop T3101

FIGURE 19

3G SYSTEM - INTRA-SYSTEM & INTERCELL HANDOVER (Successful)

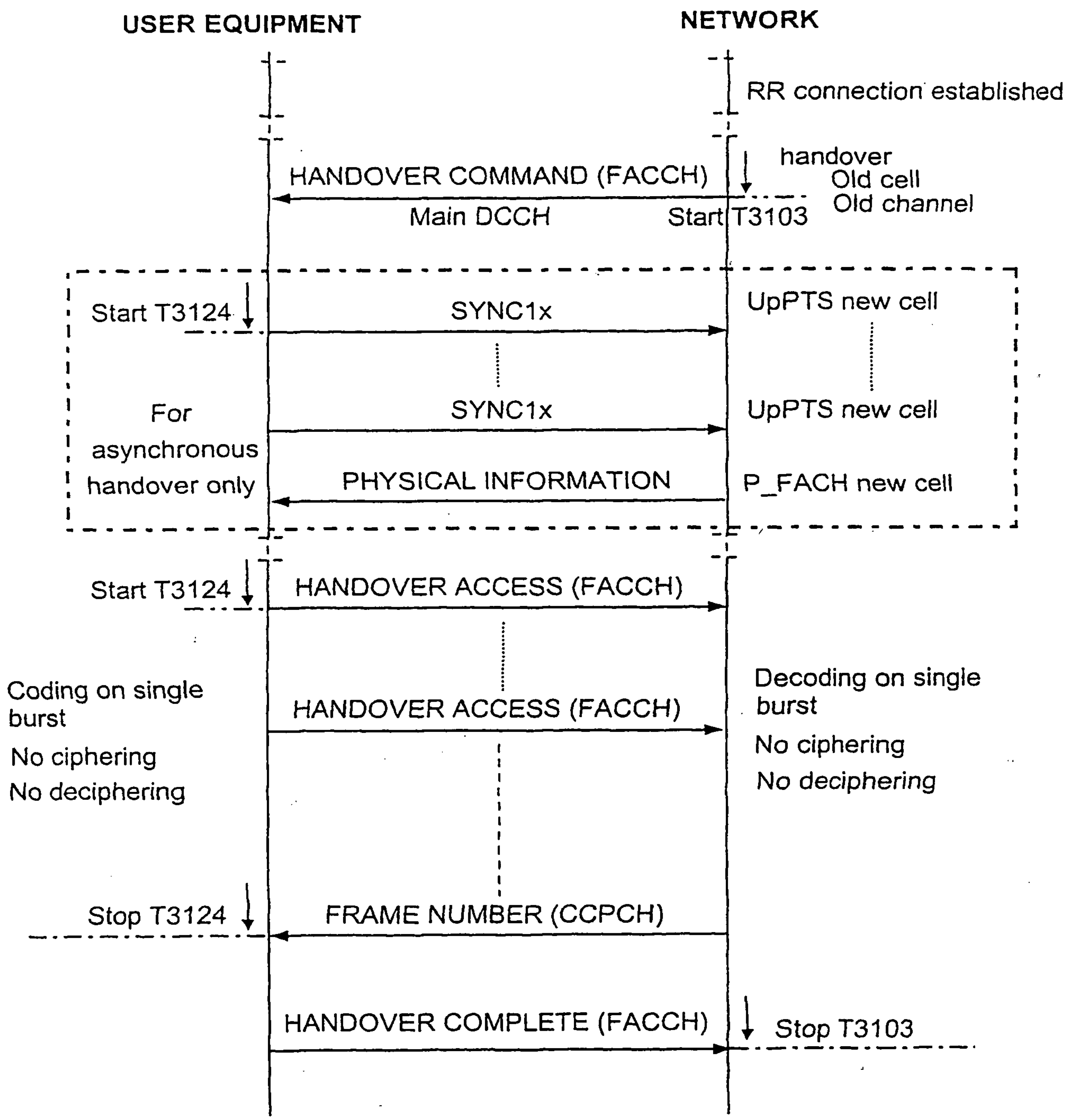


FIGURE 20

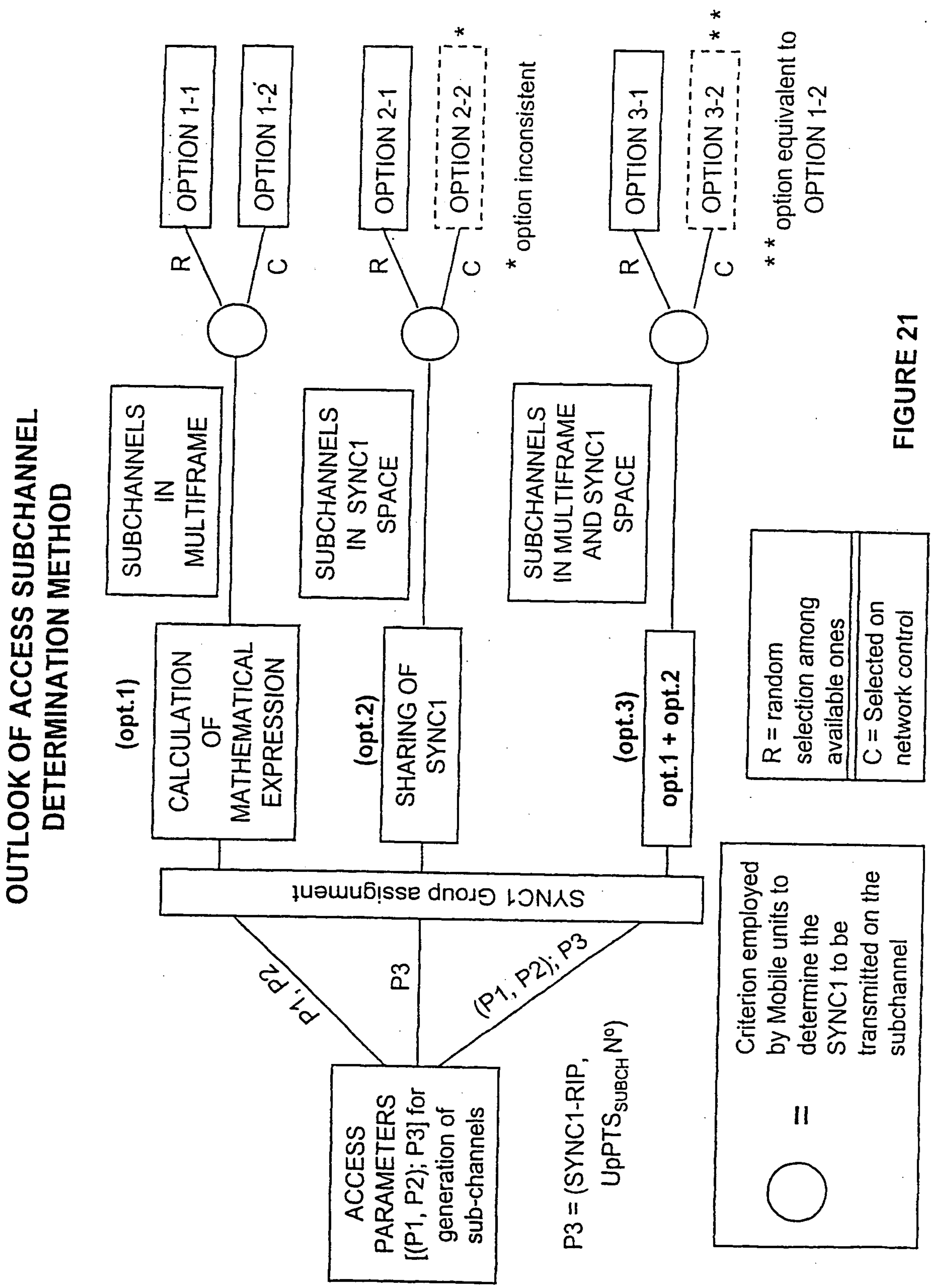

OUTLOOK OF ACCESS SUBCHANNEL DETERMINATION METHOD
ACCESS PARAMETERS [(P1, P2); P3] for generation of sub-channels
P3 = (SYNC1-RIP, UpPTS$_{SUBCH}$ N°)
P1, P2
P3
(P1, P2); P3
SYNC1 Group assignment
(opt.1)
CALCULATION OF MATHEMATICAL EXPRESSION
(opt.2)
SHARING OF SYNC1
(opt.3)
opt.1 + opt.2
SUBCHANNELS IN MULTIFRAME
SUBCHANNELS IN SYNC1 SPACE
SUBCHANNELS IN MULTIFRAME AND SYNC1 SPACE
R
C
OPTION 1-1
OPTION 1-2
OPTION 2-1
OPTION 2-2
* option inconsistent
OPTION 3-1
OPTION 3-2
* * option equivalent to OPTION 1-2
= Criterion employed by Mobile units to determine the SYNC1 to be transmitted on the subchannel
R = random selection among available ones
C = Selected on network control

FIGURE 21

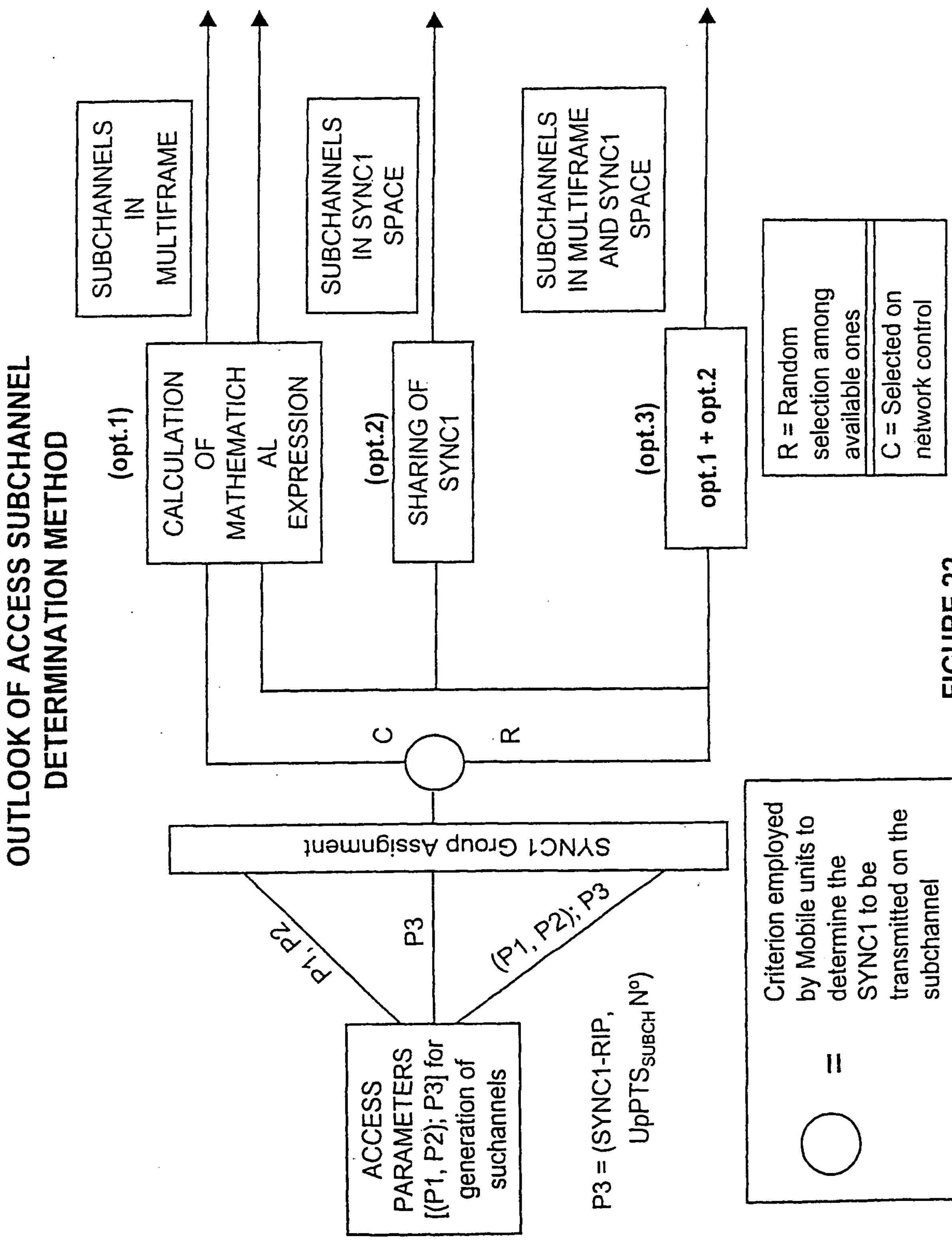

OUTLOOK OF ACCESS SUBCHANNEL DETERMINATION METHOD
ACCESS PARAMETERS [(P1, P2); P3] for generation of suchannels
P3 = (SYNC1-RIP, $UpPTS_{SUBCH}$ N°)
P1, P2
P3
(P1, P2); P3
SYNC1 Group Assignment
C
R
(opt.1)
CALCULATION OF MATHEMATICH AL EXPRESSION
(opt.2)
SHARING OF SYNC1
(opt.3)
opt.1 + opt.2
SUBCHANNELS IN MULTIFRAME
SUBCHANNELS IN SYNC1 SPACE
SUBCHANNELS IN MULTIFRAME AND SYNC1 SPACE
R = Random selection among available ones
C = Selected on network control
=
Criterion employed by Mobile units to determine the SYNC1 to be transmitted on the subchannel

FIGURE 22

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IT 00/00101

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ETSI TC-SMG: "UNIVERSAL MOBILE TELECOMMUNICATIONS SYSTEM (UMTS); UMTS TERRESTRIAL RADIO ACCESS (UTRA); CONCEPT EVALUATION (UMTS 30.06 version 3.0.0) TR101146 " EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE, December 1997 (1997-12), pages 486-590, XP002153734 page 516 -page 517, paragraph 4.2.3 ---	1,16
A	EP 0 587 980 A (ROKE MANOR RESEARCH) 23 March 1994 (1994-03-23) column 4, line 47 -column 7, line 3; figure 2 -----	1,16

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"E" earlier document but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 November 2000	11/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bocking, P

INTERNATIONAL SEARCH REPORT

Information on patent family members

Internati, Application No
PCT/IT 00/00101

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0587980 A	23-03-1994	GB 2270815 A	23-03-1994
		DE 69328892 D	27-07-2000
		DE 69328892 T	26-10-2000
		ES 2148192 T	16-10-2000
		FI 934088 A	19-03-1994

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